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MONITORING FOR CHANGE: WORKSHOP PROCEEDINGS

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Land Use in Canada Series Number 28

MONITORING FOR CHANGE: WORKSHOP PROCEEDINGS

September 30 – October 3, 1985
Ottawa, Ontario

Paul C. Rump
Norah M. Hillary
Editors

CANADA LAND USE MONITORING PROGRAM

Lands Directorate
Environment Canada

Ottawa
June 1987

LAND USE IN CANADA SERIES

The *Land Use in Canada Series* is designed to address major land-use issues and problems in Canada. The series, produced by and for the Lands Directorate of Environment Canada, examines the causes and consequences of major land problems and land-use trends throughout Canada and the role of various government programs in eliciting solutions.

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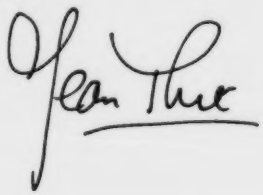
PREFACE

Canada's economy is highly dependent on the environment, including the land base. At the same time, the land available for specific economic activities, such as agriculture, is often limited. In addition, the opportunities for expanding onto new land without incurring land-use conflicts are over. Sound management of the land resource on a sustainable basis is required to ensure the optimal allocation and use of the land. The achievement of economic growth and development goals must be balanced against the maintenance and enhancement of environmental quality.

Monitoring of land-use and land-degradation change over time is an essential component of a sound resource management system. Informed decisions concerning the use and protection of land can only be made with the benefit of credible, consistent, and compatible time-series data. From monitoring programs, resource managers can obtain scientifically-based perspectives on past circumstances, present conditions, and future scenarios based on data projections. To be successful, monitoring must focus on current land issues, but be sufficiently stable to provide continuity.

The history and scope of land monitoring in Canada is not extensive. Most of the activity derives from projects where time-series land data are required to meet relatively specific objectives. In 1978, the Canada Land Use Monitoring Program was established by Lands Directorate to provide data on the amount, type, and location of land-use change and to provide assessments of the significance of this change from national and sustainable resource perspectives. In particular, the program focusses on Canada's limited prime resource lands. Despite this federal focus, land-use change research and researchers tend to be relatively isolated and not well linked as a cohesive and mutually supportive force.

The convening of a national workshop was seen as a means for bringing researchers, policy advisers, and resource managers together to exchange information and experience, to develop common understanding and appreciation, and to initiate closer links and relationships. If this forum helps to improve the monitoring response to land issues and expands the overall awareness of land monitoring's contribution to sound natural resources management, it will have successfully fulfilled its objective.



J. Thie
Director, Lands Directorate

ABSTRACT

These proceedings consist of the edited papers and workshop summaries from the *Monitoring for Change Workshop* sponsored by the Lands Directorate, Environment Canada and held in Ottawa, September 30 to October 3, 1985. The overall objective of the Workshop was to encourage dialogue, information exchange, and cooperation in order to strengthen and enhance the land-monitoring contribution to the prevention and resolution of land-use conflicts.

Three major themes are the basis for the organization of the proceedings. Under the first, *Land-Use Monitoring and Degradation Research: Issues & Role*, papers given by representatives from across Canada provide national and regional perspectives on the role of monitoring in the prevention and resolution of land-related issues. Workshop summaries address more specific aspects of this theme such as user requirements, and priority areas and sectors which warrant a monitoring response. Papers under the second theme, *Methods and Techniques for Land-Use Change and Degradation Monitoring*, range from the use of conventional air photography and satellite imagery to municipal assessment records and geographic information systems. Problems with forest land monitoring, and techniques to predict land-degradation impacts are also presented. Workshop summaries include discussions on standards for monitoring, program integration, and the monitoring potential of existing data sets. Under the third theme, *Strategies for Cooperation*, the presentations and workshop summaries emphasize the significance of cooperation in resolving land-related problems, and the means by which this cooperation could be enhanced.

A common thread throughout the proceedings is the contribution of land-use change and land-degradation information towards improved land and natural resource management. Through the publication of the proceedings, the beneficial experience of the Workshop will be shared with a larger audience.

RÉSUMÉ

Le présent document regroupe les exposés et les compte rendus des ateliers présentés lors de l'*Atelier sur la surveillance de l'utilisation des terres* tenu à Ottawa par la Direction générale des terres d'Environnement Canada, du 30 septembre au 3 octobre 1985. L'objectif général de cet atelier était d'encourager le dialogue, l'échange d'informations et la collaboration de sorte que les activités de surveillance des terres puissent mieux contribuer à la prévention et à la résolution des conflits liés à l'utilisation du territoire.

L'atelier s'articule autour de trois grands thèmes. Le premier, *Recherche sur la surveillance de l'utilisation des terres et sur la dégradation des sols: problématique et objectifs*, a été traité par des participants de différentes régions du pays qui ont présenté une perspective nationale et régionale du rôle de la surveillance dans la prévention et la résolution des problèmes associés aux terres. Les compte rendus des ateliers portent sur des aspects particulier de ce thème, comme les besoins des utilisateurs et les secteurs prioritaires justifiant un programme de surveillance. Les exposés traitant du deuxième thème, *Méthodes et techniques de surveillance des changements d'utilisation des terres et de la dégradation des sols*, portent sur l'emploi de la photographie aérienne et de l'imagerie satellitaire, les rôles d'évaluation municipaux et les systèmes de données géographiques. On aborde également le problème que pose la surveillance des terres forestières de même que les techniques de prévision de la dégradation des sols. Les compte rendus des ateliers résument les discussions sur les normes de surveillance, l'intégration des programmes et le potentiel des données existantes comme outil de surveillance. Sous le troisième thème, *Stratégies de coopération*, les participants soulignent l'importance de la collaboration dans la recherche de solutions aux problèmes liés aux terres et examinent les façons dont on pourrait accroître cette collaboration.

Il ressort clairement de toutes les communications que l'information recueillie sur les changements d'utilisation des terres et sur la dégradation des sols est essentielle pour en arriver à une meilleure gestion des terres et des ressources naturelles. La tenue de cet atelier a constitué une expérience enrichissante que la publication du présent compte rendu permettra de partager avec un public plus large.

ACKNOWLEDGEMENTS

On behalf of the Lands Directorate, the editors would like to thank all persons who contributed to the success of the *Monitoring for Change Workshop*. We extend our gratitude to the authors of the papers for their stimulating presentations, to the workshop participants whose active involvement gave rise to a fruitful exchange of ideas and opinions, and to the workshop rapporteurs whose summaries and notes provided the basis for the documentation of the workshop sessions.

Several individuals deserve special recognition for their contributions. These include Sandra Macenko, who successfully completed the early planning and organization leading up to the Workshop itself; Jean Séguin and Michel Melançon, who assisted greatly with the Workshop organization and the publication of the proceedings; Ralph Krueger, Alan Aldred and Jean Thie, who chaired plenary sessions; and Gary Runka, whose extensive knowledge and experience in land issues played a major role in the overall outcome of the Workshop. Anne Kerr provided valuable support and advice on the organization and content of this proceedings document. Céline Parent and Margaret Poulin completed the word-processing, secretarial and hosting requirements with efficiency and skill. All members of the Canada Land Use Monitoring Committee willingly fulfilled a variety of supportive roles, while the Conservation and Protection Drafting Division provided the camera-ready copies of all figures and tables in this document.

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EXECUTIVE SUMMARY

In Canada's environmental ledger, what is the balance of the land resource account? Are our natural resources being protected and used appropriately? Is sustainable management being practiced? Are reinvestments being made for future generations? Monitoring plays a significant role in our ability to answer these questions. In particular, land-use change and land-degradation monitoring provides an audit of environmental quality maintenance and renewable resource sustainability. It serves a watchdog role, providing managers, decision-makers and the public with information on the state of Canada's land resource — information vital to its wise use and management.

The following provides a brief summary of the deliberations arising from the Monitoring for Change Workshop sessions. The summary gives a global perspective on the results and conclusions of the papers, the small-group workshops, and the plenary sessions. It also reflects the current state and future direction of land monitoring in Canada.

Canada's international reputation for its land data bases is derived from past national surveys such as the Canada Land Inventory. Current financial constraints, however, mean that the days of the major data-gathering surveys are over. Yet, analyses of the changing dynamics of land use require continuous updating of these data bases. A systematic monitoring program requires the collection of spatially-oriented data at regular intervals using a standard classification system to provide consistent, comparable results. In an attempt to meet these needs, land monitoring programs must take advantage of existing data sets. At present, there are three data sources which have the potential to provide information useful for monitoring on an on-going basis. These are census data, land survey and assessment rolls, and products from remote sensing. All three sources have been successfully used for either land-use change or land-degradation research.

Census data are an invaluable source for certain types of monitoring and will become even more useful as boundary changes between census dates are reduced or structured to accommodate comparability. The utility of the land survey and assessment roll system would increase significantly with relatively minor adjustments to incorporate land monitoring requirements. This includes the retention of records to ensure the availability of historical land data. Air photography has been a mainstay of land-monitoring research. However, increasing use will be made of satellite imagery, especially LANDSAT Thematic Mapper and SPOT data, as it becomes an operational reality. Satellite imagery is particularly efficient because of its frequency, coverage, and relatively low cost.

Existing environmental monitoring programs face a number of challenges, especially in the areas of budget efficiencies, timeliness of data output, and relevancy to resource management and decision-making. There needs to be continuity of land monitoring in areas with established data bases to take advantage of the added value from updating. But there must also be flexibility to initiate monitoring in new areas in response to emerging issues and priorities. Satellite imagery and automated geographic information systems are tools which have the greatest potential for improving monitoring effectiveness, particularly the speedy output of results. Monitoring programs should move towards facilitating the prediction and anticipation of future land-use change issues or potential land resources at risk. For these purposes, the most effective strategy may be to establish representative monitoring areas for which accurate time-series information can be obtained. As a further step, computer modelling should be incorporated into monitoring programs as part of an overall anticipatory approach.

Land monitoring is a relatively new initiative in Canada, characterized by activities which tend to be dispersed, unrelated to each other, and often narrowly focussed. To encourage a more coordinated approach, national criteria and standards need to be established to guide land-monitoring research in Canada. These would address problems related to comparability and compatibility between data sources, quality control, mapping scale, collection standards, availability of data, data selection, classification guidelines, and interpretation guidelines and assumptions. Such national criteria would provide the context for more specific regional and local monitoring programs, and thus broaden the usefulness of individual monitoring projects. To date, the federal Canada Land Use Monitoring Program is the only systematic operation in Canada that monitors land-use change at regular intervals using a common classification system. The Workshop strongly recommended the continuance of this Program and particularly its emphasis on prime resource lands where change will significantly affect productivity.

Integration of land-monitoring activities covering a variety of resource sectors is a major challenge for monitoring programs. Although there are specific monitoring requirements for individual sectors, closer integration in such areas as land use and land degradation, the land-water interface, and socio-economic and biophysical research is a means by which scarce dollars can be used more efficiently. An even more significant advantage of an integrated approach would be the increased ability to analyze cause-effect relationships; for example, the degree to which land-activity and land-cover changes affect water quality.

Communication of the results and significance of land-monitoring research is a critical area for improvement. There is a need for better communication among monitoring professionals, and better communication tailored both to decision-makers and to the public regarding the significance of monitoring for environmental quality maintenance and enhancement. Communication in the land-monitoring community could be improved by information exchange through national and regional forums, subsequent networking and a central registry of all monitoring research and researchers in Canada. In turn, researchers must provide interpretation of monitoring results through means and in forums that are appropriate for managers and decision-makers. For example, the knowledge

gained from monitoring should be applied to the evaluation of relevant legislation, policies and plans. The interpreted results should be communicated through existing committees and councils such as the Canada Committee on Land Use, the Canadian Council of Resource and Environment Ministers, and the Expert Committee on Soil Surveys. Communications to the public should include an explanation of the purpose, results and implications of monitoring research, as well as the publication of actual data and associated trends.

The present workshop represents the beginning of a new communications strategy for monitoring programs. This unique national dialogue on land-use and land-degradation monitoring will provide a reference point and guide for future land-monitoring activities in Canada. It should stimulate a new era of coordination and cooperation in land-monitoring research. Hopefully this will lead to a better appreciation by the public and decision-makers of the very important contribution of monitoring to successful renewable resources management in Canada.

I

Workshop Introduction

Opening Remarks
Setting the Stage

OPENING REMARKS

Lorette Goulet

Welcome delegates from across Canada, with representation from federal and provincial agencies, universities, and the private sector. This is the first national workshop to discuss land-resource monitoring in Canada. Monitoring activities for other resources have a relatively long history. Water monitoring, for example, was initiated in Canada in 1908. Such attention to the land resource, however, is of relatively recent occurrence.

You, the participants in this Workshop, are aware of the importance of the land resource in Canada. You are not alone. Land-use change and land degradation are public issues. The prominence of the report *Soil at Risk*, completed by the Standing Senate Committee on Agriculture, Fisheries and Forestry, is well known. Two other examples will illustrate the significance of land-resource concerns to Canadians. First, from a recently published report on environmental issues, the single issue selected for focus in a front-page article in the *Globe and Mail* was the urbanization of prime agricultural land. Second, a significant number of submissions to the recently completed MacDonald Commission voiced concern about sustainability of renewable resources. The final report of the Commission points to the need for research on the non-agricultural uses of prime arable land.

Although Canada is a large country, prime resource lands are relatively scarce. Only 5% of Canada's land can support sustained agricultural crop production. Productive forests comprise only 22% of the nation's land base. Therefore, information on land uses and land degradation which affect the long-term supply of these resources is essential.

Land is primarily a provincial responsibility under the Canadian Constitution. However, the federal government through direct ownership, fiscal support of sectoral and regional development programs, and regulatory powers strongly influences land use. The national economy is directly and profoundly influenced by the land resource. The productivity of Canada's land accounts for 40% of the GDP and provides employment for 25% of the labour force.

G. Greenberg

Lorette Goulet and Workshop participants

The federal government also has a concern over transboundary issues. Such issues are easy to recognize in terms of land degradation where, for example, soil erosion affects downstream water quality and aquatic habitat. Water quality of the Great Lakes Basin is significantly affected by land-use and land-management practices. Furthermore, the loss of good quality agricultural land in southern Ontario and the loss of prime forest land in British Columbia are examples where land-use change can put pressure on the land resources of other provinces. This is especially pertinent recognizing future goals for increased production.

In *Environment Canada*, monitoring of the basic environmental elements of air, water, and land is a significant tool in helping Canadians to determine the state and quality of resources. We need the information that monitoring programs provide to fulfill our role as environmental "auditor-general", to enable us to evaluate and improve federal programs affecting land use and land quality, and to provide support for effective policy initiatives.

The *Environmental Conservation Service* (ECS)[1] is composed of three directorates — land, water, and wildlife. Recent initiatives closely associated with ECS include the Pearse Inquiry on Federal Water Policy and the North American Waterfowl Management Plan. Both initiatives relate to the use of the land resource, especially to agricultural development and wetlands habitat. Monitoring is recognized as a key activity in evaluating the success of the waterfowl plan.

The *Canada Land Use Monitoring Program* is part of the *Lands Directorate* in ECS. Lands Directorate has the federal mandate to provide a multi-sectoral focus on land and related renewable resources from a sustainable viewpoint. It is the primary agency for the implementation of the Federal Policy on Land Use.

To date, land-use monitoring research has focussed primarily on areas and issues of federal interest. However, we recognize that other government levels, agencies, and individuals are interested in land-use change information. This is why the Workshop is an important meeting place to exchange ideas and build on consensus and cooperation.

[1]Now combined with Environmental Protection as Conservation and Protection, Environment Canada

A common theme throughout the Workshop is the contribution of land-use change and land-degradation information towards improved land- and related natural-resource management. The Workshop will examine the role of, and issues associated with, land-use and land-degradation monitoring; compare and discuss various monitoring techniques; and explore ways of cooperatively working together. It is a truly participatory occasion with most of you playing an active role: speaker, session chairperson, rapporteur, etc. Three very productive days are anticipated.

In all the workshop sessions, it is important to retain an overall appreciation of the implications of land monitoring. The results of the Workshop must reflect the need for consistency especially with respect to spatial, temporal, and land attribute classifications. A comprehensive approach should be strived for to ensure comparability between data sets. These are concerns we have at the federal level as we encourage and support the development of national land information systems and also contribute to the development of the global environmental monitoring efforts at the international level.

Best wishes for a successful Workshop. Enjoy productive deliberations. Give your views as well as listening to those of others. I wait in keen anticipation for the results.

Lorette Goulet is the Assistant Deputy Minister, Conservation & Protection, Environment Canada

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SETTING THE STAGE

Paul C. Rump

At the beginning of the Workshop, it is appropriate to provide some background on its origins. The Canada Land Use Monitoring Program was initiated in 1978 in support of the Federal Policy on Land Use. Prior to undertaking operational land monitoring, a number of program design studies were completed. These included a review of land-use and land-use change information available from municipal, regional, provincial, and federal agencies; an assessment of the needs of potential clients beyond Lands Directorate; and an evaluation of monitoring techniques for other environmental parameters and for land-use monitoring in other countries. Since then, land-use change research methodologies have been tested and monitoring projects relating to urban-centred regions and prime resource lands such as fruitlands, wetlands, and more recently, prime forest lands have been completed. Now seems an opportune time to discuss the direction of land-use change research and to do this collectively with colleagues from other agencies.

This national Workshop on land-use change and land-degradation monitoring was planned and organized under the sponsorship of Lands Directorate. Entitled *Monitoring for Change*, the Workshop marks the first time that land monitoring has been discussed in such a forum in Canada. The Workshop focusses on monitoring which may be defined as the process of repetitive observing or sensing one or more elements or indicators of the environment (in our case, land use and land degradation) according to established spatial and temporal dimensions.

I sense that everyone here has a personal commitment to the topic of change monitoring. Sixty-five people from across the country have registered for the Workshop with representatives from federal agencies, provincial and regional governments, universities, and the private sector. Your active participation at the Workshop has been encouraged and nearly 90% of the participants will fulfill a particular role such as presenting a paper, chairing or reporting on a workshop session. The agenda has been developed recognizing and using as much as possible the ideas, interests, and contributions of the participants who were contacted during the early organizational stages of the Workshop.

G. Greenberg

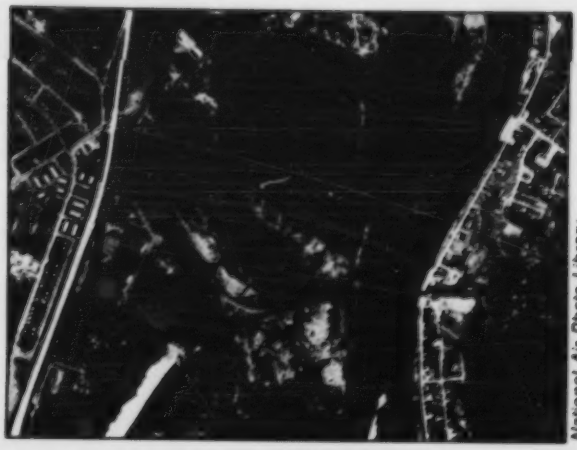
Paul Rump, Workshop moderator

The broad workshop objective is to encourage dialogue and cooperation aimed at strengthening the land-monitoring response to such issues as urbanization of agricultural land, the loss of wetlands, and land degradation. Specific objectives are:

- to provide a forum for information exchange on current land-use change and land-degradation research and methodologies;
- to expand the appreciation of the role of land monitoring in the planning and management processes for natural resources;
- to provide direction for future land-monitoring research;
- to examine ways to effectively monitor land degradation; and
- to examine the organizational needs for a coordinated and integrated approach to land-use change and land-degradation research.

The Workshop has been organized around three themes, each composed of presented papers, small-group workshops, and a plenary session. The first theme focusses on **issues and roles related to land-use monitoring and land-degradation research**. The subjects to be discussed include land issues requiring monitoring, agricultural land loss, the use of land-use change information for planning and management of recreational lands, public perception of land degradation, and the significance of land data for national policy and program formulation. In addition, these presentations have been structured to provide regional and national perspectives on land monitoring. Subsequently, small workshop groups will study the status of land-degradation and land-use change monitoring in Canada, uses and user requirements, and priority areas and sectors where monitoring is required.

Under the second theme, **methods and techniques for land-use change and degradation monitoring,** papers will be presented on the potential of remote sensing, use of assessment rolls, probability sampling, geographic information systems, forest land monitoring, and the prediction of future degradation impacts. The small workshop groups will discuss methods to monitor land degradation including integration with land-use change research, the application of remote sensing to land-use and land-quality monitoring, and the potential of using available data sets.



National Air Photo Library

National Capital Region, 1968

National Air Photo Library

National Capital Region, 1982

The Workshop's final theme of **strategies for cooperation** will be discussed in the context of both land-use and land-degradation monitoring. The papers and workshops will focus on improvements to cooperation and coordination between agencies and levels of government to increase monitoring effectiveness and to maintain data quality and comparability.

This is the first time we have met to gain the added value of an interactive group discussion on land monitoring research. I am confident our collective deliberations and individual interactions will have a positive influence on land management in Canada. As Workshop chairperson, I look forward to working with you over the next three days.

Paul C. Rump is the Chief of the Land Use Monitoring Division, Lands Directorate, Environment Canada.

II

Land-Use Monitoring and Degradation Research: Issues and Role

Papers
Workshops

LAND ISSUES AND MONITORING IN BRITISH COLUMBIA

Greg Roberts

This paper examines the role of land monitoring in the context of some major land-use issues which presently exist in British Columbia. It also assesses the "state-of-the-art" in land monitoring capability in the province and the potential for significant advances in this area resulting from the application of computerized technology.

The paper first highlights two fundamental land-use issues in British Columbia: the loss of productive forest land and the disposition of Crown lands for agriculture. It then addresses the potential contribution of land monitoring and land-use change research in the resolution of each of these issues. This analysis raises several points on the relationship between land monitoring and the decision-making process.

The second section highlights several data base and mapping programs presently in operation in British Columbia, from the perspective of their application to land monitoring. The paper concludes with a series of observations which indicate that the application of existing data base and mapping programs could provide significant opportunities for land monitoring.

INTRODUCTION

This paper focusses first on the present role of land monitoring in the resolution of major land-use issues and later, on the developing potential for land monitoring in the province, presenting a "bad news — good news" synopsis.

First, two of the major land-use issues in British Columbia and their relationship to land monitoring will be reviewed in order to initiate discussion on:

- the role of land monitoring in issue resolution;
- the problems of support for land monitoring; and
- the definition of expectations for land monitoring in the resolution of issues.

Those involved in land-use research within government organizations may view the conclusions presented as the "bad news". Second, a number of independent data base and mapping programs in use in British Columbia will be highlighted. These "good news" initiatives provide a significant opportunity for land monitoring.

LAND ISSUES

To place this land issues discussion in context, it should be noted that in British Columbia, as elsewhere in Canada and the world, we are in a period when many fundamental values are being examined, especially those surrounding the role of government in a mixed-market economy. Land-use issues do not escape this review; neither do the responsibilities of government for land allocation and management. Both the process and policies by which Crown land resources are allocated and priced are being critically questioned. The appropriate mix of land held in trust by the Crown and fee simple tenure is being re-evaluated. These fundamental issues and directions are somewhat removed from the development of programs for land monitoring. It is useful to keep them in mind, however, because the orientation adopted by Canadian society cannot help but impact upon the development and relevance of land-monitoring programs, both now and in the future.

Windermere Valley, British Columbia

A discussion of land-use issues raises the critical question: From whose perspective are the issues being defined? This question may appear simplistic. It is important, however, to be aware of the tendency of specialized groups to view the world from a particular perspective. The resource manager, politician, environmental advocate, and union representative, for example, will all undoubtedly see land-use issues from divergent perspectives. It is a precept of this paper that our professional perspective on the issue, alone, may not be particularly useful in finding a resolution. In short, in our attempt to determine the appropriate role for land monitoring, we need to be cognizant of other perceptions of land-use issues.

Two of the many land-use issues that are apparent in British Columbia have been chosen for discussion:

- **the loss of the most productive forest land;** and
- **agricultural land disposition at the margin**.

The overview presented is neither comprehensive nor conclusive, and the selection of issues is random. Nonetheless, these issues are representative of the type of land-use concerns where land monitoring has a role to play.

LOSS OF PRODUCTIVE FOREST LANDS

Loss of productive forest land has been and continues to be a major issue in British Columbia. My perception of the development of this as a public issue and the program response is outlined below.

In 1976, a Royal Commission report on forest resources was submitted to the British Columbia legislature (Pearse, 1976). This report represented the basis for comprehensive changes to the *Forest Act* (1978), including provision for the Chief Forester to designate forest land and the Lieutenant Governor in Council to establish provincial forests. Specifically, the *Forest Act* states that land shall be classified as forest land if " . . . it will provide the greatest contribution to the social and economic welfare of the province if maintained in successive crops of trees or forage, or both" (*Forest Act*, 1978).

In the late 1970s, a lobby was initiated to bring to public attention losses of the productive forest land base through such developments as hydroelectric reservoirs, transmission corridors, roads, settlements, parks, and agriculture. Government response included a program to protect forest lands through the expansion of provincial forests. Between 1979 and 1984, the area in provincial forests grew from 30 million ha to over 75 million ha. Currently, about 80% of the land base of British Columbia is under provincial forest designation, with perhaps another 10% in forest production outside provincial forest boundaries.

In response to the new provincial forest initiatives, the Ministry of Forests and the Ministry of Lands, Parks and Housing have cooperated in a planning program to exclude lands required for settlement, agriculture, or park purposes. In addition, mechanisms have been established for formal review of forest boundaries. To ensure that land uses which are compatible with forest production are not excluded by the consolidation of provincial forest boundaries, an agreement for interagency administration of non-forest uses within provincial forests has been developed. While these mechanisms carry high administrative costs, it can be argued that the costs are warranted because of the protection they give to the forest land base. Only where a strong economic argument can be made for taking the land out of forest production will land be withdrawn from the provincial forest.

In hindsight, however, one can now ask if this broad brush program could have been refined into a sharper tool for land-use control. Land-use change research perhaps could have contributed to a better understanding of the problems and the development of refined policy and program tools. Decision making regarding this program involved a large range of public and private interests. Where and how could land monitoring have been inserted into this process?

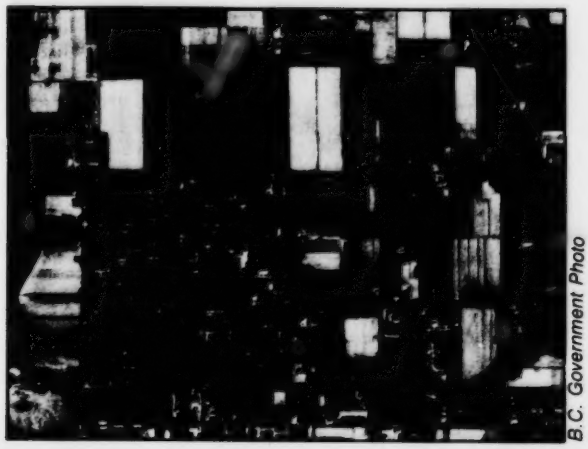
AGRICULTURAL LAND DISPOSITION

The loss of the most productive agricultural lands is a frequent topic of discussion in many Canadian provinces, including British Columbia. Loss of viable farmland and the implementation of the **Agricultural Land Reserve** (ALR) program have been specifically identified as major agricultural policy issues in the province. Now the disposition of Crown land for new agricultural development will be examined.

The issue here is whether unencumbered Crown lands should be **alienated** for agricultural development given that they are located primarily at the margin. Will such lands make a long-term contribution to increasing agricultural production in the province and thereby have a positive impact on local and/or regional economies, or are they ultimately destined to revert to forest use? Long-term benefits and costs to society are affected by the answer to this question.

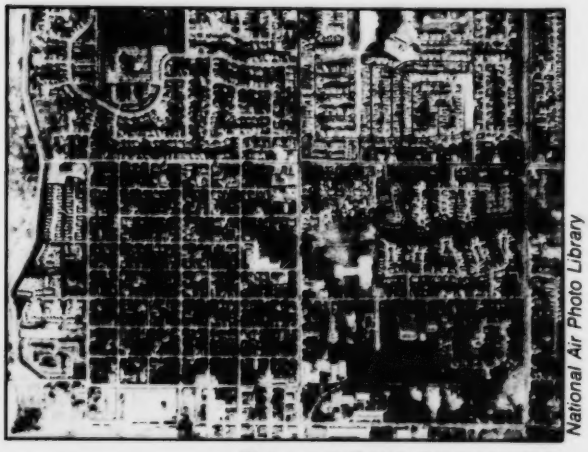
In British Columbia, the Ministry of Lands, Parks and Housing has alienated about 200 000 ha of Crown land for agricultural development over the last five years. Most of this has occurred in the Cariboo, Omineca, and Peace regions of the province. Consisting of mainly Class 4 or 4-5 complex land, according to the British Columbia Land Inventory (BCLI) agricultural capability classification, this land is suitable for improved pasture or forage production. Often the land has been the subject of some controversy regarding its most appropriate use.

The issue, appropriateness of use, as seen by the program analyst or planner, centres on the trade-offs involved, opportunity costs, options foreclosed, environmental impacts, and local and regional economic impacts. Studies have been undertaken on net present value and cost-benefit approaches in order to evaluate these trade-offs; comprehensive plans have been completed to resolve conflicts; and land-monitoring studies have and are being undertaken to better understand the dimensions of the issue. For example, in the Cariboo region a study was undertaken to analyze the relation between land use, tenure, and land suitability for agricultural development (Lands, Parks and Housing, 1985). One of the objectives



B.C. Government Photo

Richmond, British Columbia, 1966



National Air Photo Library

Richmond, British Columbia, 1982

was to determine how much of the **privately-owned** agricultural land base was developed. It was found that less than 30% was developed, while between 60% and 70% of this land base was suitable for development. Consequently, it could be predicted that agricultural production could increase substantially through the normal process of farm development without Crown land being alienated for some time. However, other program objectives, such as enhancing farm viability through expansion of existing units or in-filling in areas of predominantly private land, need to be considered in weighing the viability of agricultural development at the margin.

A comprehensive study presently being undertaken by the Ministry of Lands, Parks and Housing, which examines land-use change and its relation to Crown land tenure policy in the Vanderhoof area west of Prince George, provides another perspective on this issue. Here, the rate of agricultural development and reversion is being analyzed in relation to Crown land disposition policy and tenure variations between 1966 and 1984. The spatial aspects of land-use change will be analyzed in combination with the results of a questionnaire survey which provides an assessment of the perceptions of Crown land lessees. This study, when completed, will contribute to our understanding of agricultural land dynamics at the margin, as well as enhance the policy and programs of the Ministry. In a real way, this study will attempt to make use of land monitoring in the resolution and refinement of policy issues respecting agricultural development on Crown land.

Policy and program development is, at times, a strange and dynamic process. Clearly, **land-use change research** plays an active part in land policy and planning in British Columbia. However, often to the frustration of the researcher, planner, or analyst, it does not get the funding, manpower, or organizational support that it warrants, nor is it reflected to the extent that it should be in the decision-making process. On the other hand, provision of detailed information about land-use changes may contribute to the frustration of the decision maker because the analysis and conclusions may add complex dimensions to what might have been perceived as a straightforward problem. Part of this difficulty may be due to the differing perceptions of the issue by the different players: farmer, constituent, decision maker, planner, researcher, or analyst. As E.W. Manning (1985) has pointed out, "Canadians continue to make decisions as if the resource base was not a factor to be considered". The reasons for this fact are not clear. While land-use change research is an important part of policy and program development in British Columbia, it is clear that it is likely to get neither increased program support nor increased stature in the decision-making process; thus, the "bad news". Given this conclusion, the question to be asked is: What objectives for land-use monitoring in the policy and program-development process for land allocation and management are achievable?

LAND MONITORING

There is some "good news"! Introductory observations on the situation in British Columbia include:

- **automated data bases**, both graphic and tabular, are common and growing in use in British Columbia;
- **geo-referencing** of attribute data to digital maps is becoming more common and practical;
- **networking** of dispersed hardware systems is becoming more attractive;
- the development of new **information systems** is being driven by the necessity of increased efficiency in the primary business functions of government agencies in a period of limited funding and manpower;
- **hardware** and **software** developments are leading to an increased ability to analyze large volumes of graphic and tabular land-use data in addition to simple storage and retrieval;
- while the development of new data bases and systems is not being driven by the requirements of land-use monitoring they do allow a wide range of **enquiries of land data** for the purposes of problem definition, analysis, policy formation, and planning.

Some exciting data base and mapping programs, which provide opportunities for land-use monitoring, have been initiated in British Columbia and are briefly outlined below.

The Forest Inventory System

The forest inventory system of the Ministry of Forests provides a quantitative description of the forest and range resources of the province. As well as providing a basis for assessing the potential of land, it also enables an assessment of recreation and other forest uses. This system is designed to aggregate resource descriptions at five levels from the operational to provincial scales (Hegyi and Quenet, 1983).

When this automated system is completed, over 7 000 forest maps will be stored in digital form on an Interactive Graphics Design System (IGDS). These maps are linked to an extensive forest and land data base which is also used for annual updating of maps and producing forest use statistics pursuant to the *Forest Act*. Although this system is designed to capture information essential for forest management, it is feasible and practical to use the system's capabilities to monitor changes in land use, cover, land quality, and tenure. For example, the system has been used at the provincial level to analyze range productivity through the use of algorithms applied to forest site quality data. System adaptations to evaluate wildlife habitat are also possible. Areal calculations involving factors such as forest site quality, tenure, and environmental sensitivity are feasible and these data sets can be overlayed to determine harvesting and land-use conflicts. Land-use change research will be able to draw heavily on this system.

Crown Land Information System

The Crown Land Information System of the Ministry of Lands, Parks and Housing has been in operation for several years. Significant enhancements to this system which will provide for increased land-monitoring capabilities are now occurring. The major components of this system include:

Cadastral Mapping: A system of 7 000 maps is maintained for the province and provides the base for recording the status and encumbrances on Crown land. To date, 1 200 medium scale (1:20 000) maps have been digitized. This represents about 20% of the map sheets required to cover the province. Recent enhancements ensure that geo-referencing of the cadastral base with tenure and other attribute information will be possible.

Crown Land Registry: This system is an automated data base that identifies tenure or other interests registered against parcels of Crown land.

Tenure Administration System: This system is an automated data base used in the administration of all Crown land tenures. A common tie with the Crown land registry and the cadastral map data bases is provided through a unique parcel identification number.

The primary purpose of these information systems is to maintain the Crown land records of British Columbia. Nevertheless, the adaptation of this information to land monitoring is very promising. The development of statistics on the amount of Crown land released for various uses can be tabulated from the tenure administration system. A longer term goal for this system is to apply these data bases to the production of land status maps. In short, analysis of these data to generate a wide range of reports on land-use change will be possible.

Base and Thematic Maps

The Ministry of Environment is responsible for developing and maintaining the base maps of the province. A program is presently underway to digitize all the British Columbia Geographic System (BCGS) maps at a 1:20 000 scale. In addition, work is being undertaken on large scale maps in certain areas. The Ministry is also responsible for a wide variety of thematic maps including soils and terrain, soil inventory, and various capability maps including wildlife. This mapping is being done on the same automated systems as those identified above.

Mineral, Oil, and Natural Gas Tenure Administration

The Ministry of Energy, Mines and Petroleum Resources is also in the process of developing a system for tenure administration that is based on hardware and software configurations compatible with those identified above.

Assessment Records

The British Columbia Assessment Authority has developed a large automated data base for establishing and maintaining assessment rolls in the province. A pilot project is currently underway to determine the feasibility of geo-referencing this information with the cadastral maps maintained by Lands, Parks and Housing. If successful, it should be possible to conduct a wide range of analyses of land-use characteristics and values.

The automated data systems identified here are compatible, and networking of the systems is possible. Analytical software tools are being developed or enhanced for use in policy applications. The future for land-use change research using these systems is, in short, becoming very attractive.

CONCLUSIONS

In summary, several observations and conclusions can be drawn.

- Due to limited fiscal resources available to government in the foreseeable future, accompanied by a

J. Moore

Okanagan Valley, British Columbia

general societal view that "less government is better government", there will be a limited availability of resources for land-use monitoring. Under these circumstances, the need for, and benefit of, a provincial land-monitoring program can be questioned.

- This limited funding will be offset somewhat by increasing the efficiencies of the primary business functions of land and resource agencies, especially where revenue is affected, through the development and implementation of automated data base and mapping systems.
- The data bases that are presently being developed lend themselves to a wide variety of analyses for land-monitoring purposes. The key will be to ensure that the systems are developed with flexibility. To do this, land-monitoring requirements must be identified.
- These requirements can then be used to coordinate and negotiate the development of systems that extend beyond the needs of the primary business-users to those of the researchers, policy analysts, and planners. In this respect, coordination of existing and emerging programs rather than the development of dedicated provincial programs is essential.
- Perhaps the most significant questions relate to broader changes in our society, and how these changes will influence the nature of the institutions responsible for land allocation and management, and their relevance to the decision-making process.
- Finally, it is apparent that there is a job to be done selling to Canadians the fact that land-use research and monitoring is important. Such research and monitoring helps to maintain and increase our competitiveness in a world economy by ensuring wise allocation and management of our land and resources.

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Response from the audience:

Unidentified speaker: Are the systems that you mention linked to any sort of networking system? Also, are there constraints in the type of system that can be developed?

Greg Roberts: All of the systems are on the same hardware. There is some limited networking occurring now, but I expect that within five years there will be extensive networking of systems. In response to your second question, in terms of hardware and purchase, there are constraints at the present time but overall, in the long term there should not be. In the past, B.C. Systems Corporation has provided a central coordination of systems development in the province and has worked closely with the various ministries in the development of systems to ensure some level of compatibility.

Unidentified speaker: Will the network eventually be extended beyond the Crown lands? Do you hope it will?

Greg Roberts: Yes, extended networking would be possible. The land title system is in the process of automation as well. However, it is not a character graphic data base at this point. The nature of the relationship is not as clear as in some of the other areas, but certainly through the assessment authority, the linkage to fee simple tenures is possible.

MONITORING CHANGES IN ALBERTA'S AGRICULTURAL LAND BASE

Alfred Birch

Resource management agencies face important issues in three broad areas: the alienation and protection of resources, the development of resources, and the degradation and conservation of resources. In each of these areas information is required, both on the extent and characteristics of the physical resource base, and on the value of that resource base under alternative uses. Recent and current monitoring projects and programs in Alberta are reviewed. These include an inventory of losses and gains of agricultural land, a wetland and a "water management problems" inventory, an inventory of irrigable land, several resource capability evaluation programs, and several projects to identify actual and potential soil degradation. These projects and programs illustrate both the diversity of monitoring requirements and techniques, and the need for effective coordination.

INTRODUCTION

Government resource management agencies across Canada are faced with a wide range of important and complex issues concerning natural resource use and conservation. Resource-allocation issues arise from competition among users and interest groups. What is the socially optimal pattern of land and water allocation and what role should the market play in determining this pattern? Resource-use and conservation issues relate to investment decisions made by resource owners and managers. What development and conservation practices contribute to both private profitability and wider societal objectives, and how should the latter be promoted?

It may be helpful to discuss agricultural resource issues, information needs, and research activities under three headings: the alienation and protection of resources, the development of resources, and the degradation and conservation of resources. A primary example of the alienation and protection issue is the conversion of agricultural land to urban, industrial, or other uses. Both development and conservation are part of the broader issue of resource investment. Land and water developments such as clearing, drainage, and irrigation raise the level of agricultural productivity through investment, while conservation protects long-term productive capability.

Behind all resource issues and the related process of policy development are significant information needs. Information is required first on the resource base itself. How much exists in what categories and in what locations? What is the productivity of the resource and how have use and productivity changed, or how are they expected to change, over time? These questions cover a range of specializations and a coordinated effort is required to develop useful answers.

A second set of related questions involves the economic values and costs associated with different resource uses. What are the benefits and costs associated with different resource-use alternatives, and how are these benefits and costs distributed? Some public values cannot be easily expressed in economic terms, and therefore, information in both physical and economic terms is required for resource policy formulation and for advising resource users such as farmers. Research on both the physical resource base and on resource values is required in order to deal with the issues of protection, development, and conservation.

The objective of this paper is to review a number of current agricultural resource-monitoring and research projects in Alberta. These projects deal primarily with the physical characteristics and allocation of the resource base, although some also involve research on resource values and costs. Projects are organized under the three headings of alienation and protection, development, and degradation and conservation.

E.W. Manning

Pivot irrigation system, Milk River Watershed, Alberta

ALIENATION AND PROTECTION OF AGRICULTURAL LAND

During the 1970s, the level of economic activity and the population of Alberta grew considerably, resulting in a corresponding growth in urban, industrial, and other non-agricultural development. This development and its impact on the province's agricultural land base caused much public concern. In response, Alberta Agriculture initiated a monitoring project to determine the rate and types of change in the province's agricultural land base (Birch, 1982; Woloshyn, 1983).

This **Inventory of Changes in Alberta's Agricultural Land Base** project examined both losses of agricultural land to urban, industrial, and other non-agricultural uses, and gains from the development of land for agricultural production. Information was collected from government files on the various categories of change. Details on rural subdivisions for non-agricultural purposes were collected from regional planning commissions and other agencies which act as subdivision-approving authorities. Similar information on urban annexation and on the development of roads, oil and gas wells, gas plants, and coal strip mines was collected from the respective administrative agencies. The provincial Public Lands Division provided details on public lands made available for agricultural production.

The data gathered in each category included the acreage, date and type of change, and the legal location (quarter section). The legal description was used to determine the Canada Land Inventory (CLI) class of agricultural capability by cross-referencing with a data base maintained by Alberta Municipal Affairs. The legal description also made it possible to summarize the inventory results on the basis of rural municipalities and regions within the province.

Between 1976 and 1981, total additions to Alberta's land in agricultural production amounted to 202 350 ha, while losses of agricultural land totalled 191 420 ha, giving a net gain of 10 930 ha. However, these figures mask the more important finding of a net loss of 35 208 ha of agricultural land in CLI classes 1 to 3, and a net gain of 46 135 ha of lower capability land in agricultural production. In addition to these shifts in the agricultural quality of losses and gains from the agricultural land base, locational shifts occurred. There was a net loss of agricultural land in southern and central Alberta, and a significant gain in agricultural acreage in the province's northern Peace River region. The net change occurring during the 1976 to 1981 period was small in relation to the total agricultural land base in Alberta, but it had important implications for farm production costs, yields, and the financial risk borne by farmers.

Due to rising concerns over changes in the province's agricultural land base and their consequences for the rural and provincial economies, the government directed the Environment Council of Alberta to conduct public hearings on the maintenance and expansion of the agricultural land base. Some of the Council's background papers used the data from the inventory project described earlier. The Council's documents provide much useful information on the protection, development, and conservation of agricultural land in Alberta (Environment Council of Alberta, 1984 and 1985).

DEVELOPMENT OF AGRICULTURAL LAND

Several monitoring projects concerning the development of agricultural land have been undertaken in Alberta. Some of these studies address a single issue or opportunity, while others are ongoing resource evaluation programs supporting the land-development and administration activities of various government agencies.

The **Inventory of Alberta's Drainage Requirements** was initiated in 1983 to produce an inventory of wetlands in the agricultural portion of Alberta and assess the feasibility or potential for drainage of these wetlands. The study is being coordinated by the Alberta Departments of Agriculture, Environment, and Energy and Natural Resources, with major funding from the provincial Water Resources Commission. Drainage is being analyzed from a multidisciplinary perspective, taking into account expected agricultural benefits and the impacts of drainage on downstream hydrology and wildlife habitat.

The wetland inventory portion of the study began with the selection of a monitoring technique based on accuracy, feasibility, and cost effectiveness, along with the refinement of a wetland classification system which would relate the inventory results to the analysis of drainage feasibility. Several monitoring techniques were compared, including different types of remote sensing, CLI maps, and municipal farmland tax assessment sheets. Current colour infrared aerial photography gave the most accurate results with good cost effectiveness and feasibility. The precise methods and comparative results are provided in Intera Technologies Ltd., *et al.* (1984), Intera Technologies Ltd. (1984), and Kerr and Young (1984).

To implement monitoring using colour infrared remote sensing, 340 townships (each 93 km^2) were photographed. These townships were randomly distributed throughout the agricultural area of the province. A stratified random subsample of these photographs was selected and interpreted based on the wetland classification system developed in the study, and the results were digitized. The classification system categorizes wetlands under nine headings including type, permanency, and wetland and upland ground cover. The preliminary results of the inventory indicate that there are approximately 4 452 000 ha of wetland in the agricultural area of the province. However, these are not evenly distributed. Excess moisture affects 2% to 5% of the land area in southern Alberta, and 30% to 33% in the agricultural portion of northern Alberta.

The inventory of Alberta's Drainage Requirements forms a portion of another, more comprehensive study of agricultural development opportunities, called the **Alberta Agricultural Land Base Study**. This latter study relies primarily on existing information sources such as CLI maps, census data, and resource specialists, rather than original resource monitoring.

The **Sub-Basin Water Management Planning Program** is similar in several respects to the drainage inventory study described above, but its objectives and approach differ somewhat. It is limited to the Peace River region of Alberta and is intended to produce: a) an inventory of drainage, soil erosion, and flood control problems; b) a ranking of small watersheds on the basis of problem severity; and c) conceptual water management plans for these watersheds.

The inventory of water management problems in this project will be based on a review of administrative files and the information collected from public information exchange meetings. Considerable file information on drainage, erosion, and flooding problems is held by Alberta Environment (which is leading this project), and by other provincial government departments and local rural municipalities. This information is being collected on summary sheets for computerization, and is being mapped at a 1:100 000 scale. Public meetings with farmers and other local residents will provide information on additional water management problems. Local advisory teams in each rural municipality have been appointed to assist in collecting information and priorizing problems and watersheds. This ranking will affect the order in which subsequent water management planning and the implementation of solutions are undertaken.

Inventory of Irrigable Land

One of the major agricultural development opportunities in southern and southeastern Alberta is the expansion of irrigation. It has been estimated that there are 3 642 000 ha that have fair or good physical potential for irrigation, although the availability of water limits potential expansion to a much smaller area. To plan for the development of water storage and distribution systems, the location of irrigable lands must be known with reasonable accuracy. The **Inventory of Irrigable Land** is an accelerated soil survey program designed to cover 971 000 ha in four years. The work is being concentrated in areas where irrigable potential, the feasibility of water delivery, and the demand for water all appear to be good.

Irrigation-potential analysis, similar to other soil survey work, employs a combination of aerial photograph interpretation, detailed site inspection, and laboratory soil analysis. This project is being coordinated by Alberta Agriculture and Alberta Environment and funded largely by the Alberta Water Resources Commission. Approximately 405 000 ha have been surveyed to date.

Other Resource Capability Evaluation Programs

The monitoring projects described above are directed at specific agricultural resource development opportunities and information needs. In addition, there are a variety of ongoing monitoring and evaluation programs which provide information for corresponding resource development and management activities in Alberta. Although there may appear to be some redundancy in these monitoring programs, they serve the needs of agencies with differing resource mandates. The challenge is not so much one of avoiding direct duplication as it is of achieving consistency of approach. Attempts are being made to achieve greater coordination, as described below.

The objective of the **Integrated Resource Management Program**, administered by Alberta Forestry, Lands and Wildlife (formerly Energy and Natural Resources), is to optimize the use of provincial publicly-owned lands and mineral resources through multiple-use planning. This planning is conducted at various scales and involves joint input from all those provincial agencies having a significant resource-related mandate. Information requirements are met through a combination of remote sensing and field survey techniques relating to the ecological and soil resources in the identified areas.

Alberta Forestry, Lands and Wildlife also carries out more specific agricultural resource evaluations under its public land disposition programs. Following on-site inspection, referral to other interested government agencies, and an assessment of adequate access, land can be posted for cultivation, grazing, hay production, or other purposes.

Alberta Municipal Affairs is responsible for maintaining a uniform basis for **farmland assessment** in Alberta. Through the use of aerial photographs and on-site inspections, and following procedures outlined in its farmland assessment manual, the department conducts periodic re-assessment of the agricultural productivity of land parcels (Alberta Municipal Affairs, 1984). This land rating system emphasizes soil and topographic features and also recognizes access and proximity to urban centres.

In addition to the irrigable land inventory described above, Alberta Agriculture has an ongoing program of **Irrigation Land Classification**. Only lands suitable for irrigation will be approved for water licensing, either within an organized irrigation district or as a private development. Irrigation land classification is carried out at various scales, depending on the planning purpose and required level of detail. Data collection involves the use of field inspections, aerial photograph interpretation, and soil analysis.

On a broader scale, **soil survey** activities in Alberta are undertaken by both Agriculture Canada and the Alberta Research Council. Information is produced regarding agricultural capability, management of problem soils, the potential productivity of soils under different management techniques, and the potential impact of various resource developments. Soil survey information has a wide range of users and potential applications in agricultural development and in protection and conservation issues. A tool for applying soil survey and other information to a wide range of resource-management issues is described in the next section.

DEGRADATION AND CONSERVATION OF AGRICULTURAL LAND

Soil and water conservation have become very prominent issues across Canada. Reports from the Standing Senate Committee on Agriculture, Fisheries and Forestry (1984), Agriculture Canada (1983), and others have pointed to the critical nature of various types of degradation and the need to implement appropriate measures quickly. In Alberta, there have been a limited number of conservation monitoring activities in the past but more are planned in the future.

Wind Erosion Alert

This program was undertaken by Alberta Agriculture during the winter of 1984-85. Forms for recording wind erosion damage were distributed to provincial district agriculturalists and municipal agricultural fieldmen. Information collected included date, location, area and extent of damage, and crop management information. Since participation was voluntary, coverage of the erosion-prone areas of the province was incomplete. However, some useful information was compiled. The program is expected to be continued in the 1985-86 winter.

Erosion and Salinity Surveys

Alberta Agriculture has developed a procedures manual, for use by municipalities, to identify the extent and severity of wind and water erosion and soil salinity problems (Alberta Agriculture, 1985). While this identification is critical for developing conservation and reclamation plans, it will also assist in building a more comprehensive picture of soil degradation across the province. The manual describes preliminary, detailed, and comprehensive survey levels, and the costs and requirements associated with each.

Wind and Water Erosion Hazard Identification

A map entitled *Soil Erosion Potential of Wind in Alberta* was compiled by Alberta Agriculture in 1985, based on 30 years of wind speed records. Actual soil erosion also depends on the erodibility of the soil as determined by soil composition and structure, moisture content, surface roughness, and degree of cover. Most of these factors are influenced by agricultural practices, none of which were included in the map.

Water erosion hazard estimations are based on information contained in a computerized data base called **SIDMAP** (Soil Inventory Database for Management and Planning) (Patterson and Peterson, 1984). This system, based on quarter-section cells, contains information on soil crop units from soil survey maps for Alberta, agricultural capability and agroclimatic ratings from CLI maps, and municipal boundaries. Single factors or characteristics can be extracted, mapped and statistically summarized, or multiple factors can be combined to indicate degradation hazard, development potential, or various other interpreted indicators. The SIDMAP system can also be merged with information on crop yields and certain management practices, allowing a generalized analysis of yields, and soil and land characteristics. Agriculture Canada and Alberta Agriculture jointly developed and continue to manage the system. The federal agriculture department will be conducting further research on cropping systems, their land base, and economic consequences using, primarily, the SIDMAP system. Although this system is a data base and research tool, rather than a monitoring project, it amalgamates information from a number of monitoring systems and permits analysis and projection of resource-use patterns. In addition, the water erosion hazard has been mapped by Agriculture Canada using the Universal Soil Loss Equation (USLE) modified to some extent to suit Alberta conditions.

Salinity Monitoring

Several salinity monitoring projects have been undertaken recently in Alberta. However, much more research is necessary to develop a comprehensive and accurate estimate of the extent of this form of soil degradation. Agriculture Canada employed a combination of satellite imagery, aerial photography, and field surveys in a study of about 8.5 million ha in southern and eastern Alberta (Thompson, *et al.*, 1981). The results indicated there are approximately 1 million ha of saline soil at a mapping scale of 1:250 000. Agriculture Canada is planning to undertake further work on erosion and salinity monitoring in conjunction with other groups in Alberta. Alberta Agriculture has also collected information on salinity through district agriculturalist reports and small area projects.

Prairie Farm Rehabilitation Administration

Wind erosion near Lethbridge, Alberta

CONCLUSIONS

This review of current and recent resource-monitoring activities in Alberta illustrates the diversity of research being conducted. Both short- and long-term information needs are being addressed. Short-term information needs relate to immediate opportunities and issues such as resource-program or policy development. The current subject of drainage development in Alberta is an example of this short-term research requirement, while five years ago, agricultural land preservation was a predominant issue. Soil and water conservation are also critical, immediate issues, but they exhibit long-term characteristics as well. Irrigation and public lands development for agricultural use are also long-run issues because of the large planning and investment requirements.

Accompanying the great variety of resource-monitoring requirements is the corresponding need for monitoring techniques. The studies reviewed above have been based on administrative files, remote sensing including both satellite imagery and aerial photography, and field surveys. The type of data collected, the classification system employed, and the scale of analysis also need to be matched with monitoring objectives, and time and budget constraints.

The clearest conclusion drawn from this review is the need for coordination in resource monitoring. **Effective coordination** will reduce costs by preventing duplication of effort, and provide more diverse information suitable for multi-disciplinary analysis. Coordination will also improve the quality of monitoring results as procedures are compared and refined. Greater consistency of approach will mean greater public acceptability of results.

In Alberta, there are several examples of increased coordination of resource monitoring and research. The **Alberta Soil and Land Inventory Coordinating Committee**, with representation from the federal and provincial governments and universities, was established recently to provide a forum for regular discussion between the major resource-management and research agencies in the province. The **Alberta Soils Advisory Committee**, under the federal and provincial agricultural advisory system, has subcommittees and working

groups which provide coordination to resource monitoring and research. One working group is developing a common system for rating arable land in Alberta while another is reviewing information needs regarding the economics of soil conservation. Annual **soil science workshops** in Alberta also bring together professionals from a variety of related fields to exchange research results. At various scales, systems like **SIDMAP** and the provincial **Land Related Information System** provide coordination of information bases and greater resource-research capability. Various resource-information catalogues such as the **Natural Resources Information Directory 1985** also contribute to coordination (Alberta Energy and Natural Resources, 1985). All activities of this type are potentially beneficial and should be encouraged. Only well-designed and supported monitoring and research will be effective in addressing contemporary resource issues.

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FARMLAND CONVERSION IN THE WINNIPEG REGION

Bruce MacLean

As in other areas of Canada, the Winnipeg Region witnessed tremendous growth in rural residential development during the 1970s. In response to concerns that the agricultural industry would suffer if this uncontrolled development was allowed to continue without proper regulations, exhaustive land-use studies were undertaken. In 1976 a new Planning Act was introduced and in 1980, new Provincial Land Use Policies were adopted.

Although the new policies were in effect, land continued to be lost from agricultural production with over 3 000 ha of prime land in the Winnipeg Region being converted to non-farm uses between 1976 and 1984. While failing to meet all of the planning objectives, the new policies did result in the refusal of a large number of subdivision applications. These refusals prevented over 3 400 ha of agricultural land from being subdivided for non-farm uses. With this experience, it is now appropriate to review current policies to ensure that the agricultural industry is better protected in the future.

INTRODUCTION

Like many regions of Canada, Manitoba witnessed rapid growth in rural residential development during the 1960s and 1970s. While the conversion from agricultural uses to non-agricultural uses did not approach the 10 ha hour rate reported in Ontario (Hoffman, 1980), large areas of prime farmland were converted to non-agricultural uses.

Although some growth was located around an expanding Winnipeg, most of the conversion occurred in the rural agricultural municipalities adjacent to the city. For example, in the Rural Municipality (RM) of Springfield, located immediately east of Winnipeg, the population increased 51% between 1971 and 1981, from 5 950 to 8 986 (Statistics Canada, 1981). In contrast, the City of Winnipeg experienced an increase of only 5% during the same period. This rural growth caused concern in government. Consequently, a number of studies were undertaken to examine the possible negative impacts of this growth on Manitoba's agricultural industry.

According to a 1973 study, many rural residential land owners in the RM of Springfield moved to the country because of lower land costs, lower taxes, and country life in general (Paterson Planning and Research Ltd., 1973). However, 25% of those surveyed mentioned that they were bothered by neighbouring farm activities. Results from a University of Manitoba study, revealed that similar attitudes were present in other municipalities in the Winnipeg Region (Carvalho, 1974). Another 1973 report concluded that rural residential development affected assessment rates on adjacent farmland, and that further uncontrolled development would cause land-use problems (Riddell, Stead and Associates, 1973). The report recommended that the provincial government develop planning policies to guide rural residential uses.

While the concern about the loss of farmland was rising, no figures on the magnitude of the problem were available. This issue was addressed in 1977 when a study released by the Manitoba Department of Municipal Affairs showed how much farmland had been subdivided for non-farm uses. It reported that in 1976 alone, 3 688 ha of farmland had been subdivided for non-farm uses in rural Manitoba. Finally, on January 1, 1976, a new *Planning Act* was adopted, making it mandatory for all land subdivisions to be both registered and to go through a detailed referral process. Under the previous *Planning Act*, legally described subdivisions could be approved without referral to any government departments, including the Manitoba Department of Agriculture. Although the new *Planning Act* gave all concerned provincial government departments the opportunity to review and assess the impact of all proposed land subdivisions, there was no overall policy to guide the reviewers in decision making.

The Winnipeg Region Study suggested that 18 different land-use policies be implemented to protect both agricultural and other non-renewable resources (Manitoba Department of Municipal Affairs, 1976). In June 1978, a new set of provincial land-use guidelines was released by the Government of Manitoba. These guidelines were further refined and in November 1980, Manitoba Regulation #217 80 entitled *Provincial Land Use Policies* came into effect under the *Planning Act* (Government of Manitoba, 1980).

Manitoba now possesses the necessary legislation to review properly all subdivision proposals and to ensure that all local planning documents meet provincial requirements. Under the new *Planning Act*, once a municipal plan has been approved, the *Provincial Land Use Policies* can be appealed by the municipality.

NEED FOR A MONITORING SYSTEM

Although the subdivision review process and the *Provincial Land Use Policies* were in effect, land continued to be lost from agricultural production. However, no statistics had been kept to determine the amount of land involved. For the effectiveness of the *Provincial Land Use Policies* and of the various local planning documents to be evaluated, this information was essential. To this end, data on all subdivision applications were stored for future retrieval on a computerized system developed by the Manitoba Department of Agriculture. The system categorized all applications according to geographic location, previous and proposed land use, and recorded other relevant data including Canada Land Inventory (CLI) classifications and number of lots. A similar system employed in Ontario served as a guide in the development of the Manitoba system.

When a subdivision application has been given tentative approval by the Manitoba Department of Municipal Affairs, a subdivision form is completed and the information stored in the computer. This form contains all the information necessary to make very accurate estimates of the amount of agricultural land lost to other uses, and the quality of the land affected. The information on subdivisions includes location, status and planning action, present and proposed land use, CLI agricultural capability, and size of subdivision. Table 1 illustrates the kind of data that is available after computer analysis. This example indicates there were 38 subdivision applications in the RM of Brokenhead in 1979, 27 of which were approved and 11 rejected. Consequently, 127 ha of agricultural land were removed from production. Most of this land (112 ha) was used for non-farm residential development.

THE WINNIPEG REGION

Prior to the implementation of the *Provincial Land Use Policies* in 1980, there had been uncontrolled growth of rural residential development in the Winnipeg Region. Most of this expansion was concentrated in the area stretching from the RM of Ritchot south of Winnipeg to the RM of Rosser northwest of the city

Table 1
1979 Subdivisions
RM of Brokenhead, Manitoba

Summary of Hectares Subdivided by CLI Class*

CLI Class	2	3	4	5	Total	No. of Applications
Land Use						
Previous:						
Agriculture	4	121	47	36	208	17
Farm Residence	4	10	0	0	14	5
Non-Farm Residence	0	3	0	0	3	2
Non-Agricultural	0	2	4	2	8	3
Proposed:						
Agriculture	0	49	16	16	81	4
Non-Farm Residence	8	78	34	18	138	20
Commercial	0	7	0	0	7	1
Urban Residential	0	3	0	4	7	2
Total	8	136	51	38	233	27

Summary of Agricultural Hectares Subdivided by CLI Class*

CLI Class	2	3	4	5	Total	No. of Applications
Land Use						
Previous:						
Agriculture	4	121	47	36	208	17
Proposed:						
Agriculture	0	49	16	16	81	4
Non-Farm Residence	4	62	30	16	112	10
Commercial	0	7	0	0	7	1
Urban Residential	0	3	0	4	7	2

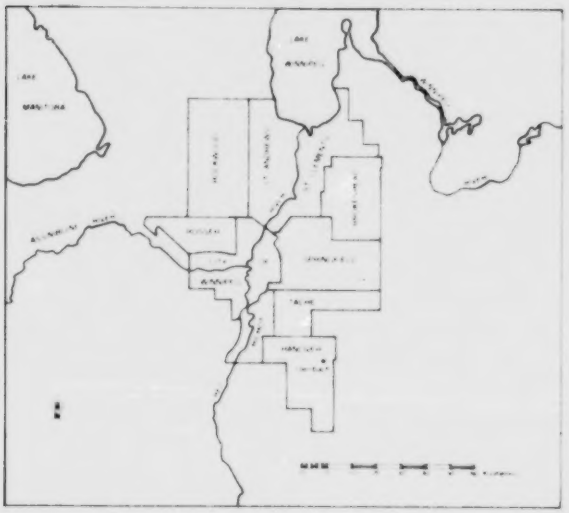
Application Status

	Interim	Finalized	Approved	Rejected
Applications Processed	0	38	27	11

*No subdivisions have affected classes 1, 6, 7 or organic soils

Numbers may not add due to rounding

Figure 1
Winnipeg Region Study Area



(*see* Figure 1). The patterns were typical of other areas undergoing land-use change. There was a rise in the number of hobby and horse farms, a decline in livestock numbers, and a rise in the amount of land owned by non-farmers. A study of the land ownership pattern in the RM of Springfield revealed that 38% of all privately-owned land in the municipality was owned by non-farmers (MacLean, 1983). While part-time and full-time farmers still owned the majority of the farmland, their attitude was that an increased amount of rural residential development was inevitable and that the traditional agricultural industry in the municipality was doomed.

It has been nine years since the initiation of the subdivision referral process and over five years since the adoption of the *Provincial Land Use Policies*. During that period, hundreds of subdivision applications have been reviewed and the effectiveness of the provincial and local policies is now being questioned. Some of the local policy documents, while giving the pretence of protecting agricultural land, have designated excessive areas for rural residential development and have left large loopholes in their agricultural policies. For example, in the RM of Hanover, land subdivisions for family members are, for all practical purposes, exempt from subdivision controls.

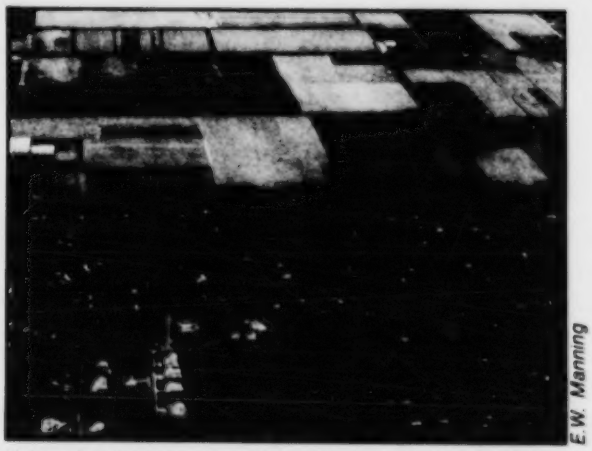
One of the main goals of the planning department is to protect farmland and to encourage growth in rural settlement centres, yet Friesen (1985) found that the opposite has been happening. In 1982, 1 600 ha of rural land had been subdivided for future rural residential use, compared with 232 ha in rural settlement centres, and only 108 ha in the City of Winnipeg. This study also noted that the subdivided land within the City of Winnipeg could accommodate 1 881 dwellings, while the rural residential lots could accommodate only 803 new houses. The latter figure could increase through future subdivisions.

LAND LOST IN THE WINNIPEG REGION

This discussion centres on municipalities near Winnipeg that have witnessed the greatest growth in rural residential development between 1976 and 1984. These are the RMs of Rosser, Rockwood, St. Andrews, St. Clements, Brokenhead, Springfield, Tache, and Ritchot (*see* Figure 1). Extracting subdivision data for periods prior to 1982 involved reviewing over 2 000 files. Subdivision data for 1982-1984 was retrieved through use of the Manitoba Department of Agriculture's computer system. Analysis of the 1976 and 1977 files for the RMs of Rosser, Rockwood, St. Andrews, and St. Clements this winter will complete the project. Table 2 shows the amount of agricultural land that was subdivided between 1976 and 1984 in the Winnipeg Region. During this period, over 3 000 ha of farmland were subdivided for non-farm uses. In addition, it is estimated that another 500 ha of land were subdivided in 1976 and 1977 in the municipalities which have not yet been analyzed. Subdivision rates remained fairly constant between 1976 and 1980, with 400 ha to 600 ha subdivided annually. However the amount of agricultural land lost through subdivision declined significantly after 1980.

The extent of land that had been subdivided varied considerably between municipalities. The RM of Hanover, located approximately 100 km southeast of Winnipeg, experienced the greatest amount of growth of the nine municipalities (*see* Table 2). Between 1976 and 1984, over 800 ha of agricultural land were subdivided for non-farm uses in Hanover. Most of this transition occurred around the town of Steinbach which is within commuting distance of the City of Winnipeg. Between 1971 and 1981, the population of Steinbach grew from 5 265 to 6 676 (27% increase). At the same time, the RM of Hanover increased from 6 169 to 7 428 (20% increase). Other rural municipalities within the study area such as Ritchot and Rosser witnessed very little growth between 1976 and 1984. In Ritchot, only 103 ha of land were subdivided and in Rosser, only 27 ha were subdivided between 1978 and 1984. This wide variation between municipalities can be attributed to a number of factors.

Generally, the municipalities with the greatest subdivision activity also have an economically viable and growing centre, such as Steinbach. Neither Ritchot nor Rosser municipalities have such a centre. Settlement patterns prior to 1976 also have had a pronounced effect on subsequent subdivision patterns.



E.W. Manning

Urban development on prime agricultural land, Lulu Island, British Columbia

Table 2
Agricultural Land Subdivided for Non-Agricultural Uses in the Winnipeg Region, 1976–1984[1]

Year	Rural Municipality (ha)									Town (ha)	Total (ha)
	Brokenhead	Hanover	Ritchot	Rockwood	Rosser	St. Andrews	St. Clements	Springfield	Tache	Steinbach	
1976	53	226	8	NA	NA	NA	NA	98	62	0	447*
1977	66	66	35	NA	NA	NA	NA	104	71	34	376*
1978	23	166	12	38	6	71	22	24	57	3	422
1979	125	110	0	162	0	34	88	15	37	1	572
1980	67	79	16	10	11	83	105	23	29	2	425
1981	8	85	3	4	2	35	28	22	14	0	201
1982	14	33	18	20	0	12	67	24	18	68	274
1983	18	14	11	18	1	24	27	33	0	0	146
1984	14	23	0	20	7	55	7	15	14	0	155
Total	388	802	103	272**	27**	314**	344**	358	302	108	3018

[1] Excluding Winnipeg Additional Zone
* Incomplete data for year
** Incomplete data for municipality
NA Not available

In areas that had been highly subdivided prior to 1976, the settlement pattern continued. Often these subdivided areas were designated as rural residential areas in subsequent planning documents, although the dominant land use was still agriculture.

Local politics have also played a significant role in influencing settlement patterns. There have been pro-planning councils and anti-planning councils. Generally, the planning documents in municipalities that have anti-planning councils tend to provide less protection for the agricultural land base. More land is included in rural residential zones, and the criteria used to allow development within the agricultural zones is less rigid.

THE EFFECTIVENESS OF PROVINCIAL AND LOCAL PLANNING DOCUMENTS

Although provincial and local planning policies are in effect, agricultural land in rural Manitoba is still being converted to non-farm development. Unfortunately, since there is no means of determining the amount of land that had been subdivided in the years prior to the implementation of the new *Planning Act* in 1976, there is no base from which to compare subsequent subdivision activity. The years 1976 and 1977 were, however, a transition period. While the *Planning Act* of 1976 established the subdivision procedure, the government referral process took many months to operate smoothly. In addition, there were no consistent criteria to assess subdivision applications during this period. As a result, many subdivisions in 1976 and 1977 escaped proper evaluation. The system did not begin to operate effectively until 1978.

An analysis of the annual loss of farmland between 1976 and 1984 showed that no significant decline became apparent until 1981 (*see* Table 2). Since then, there has been a slow decline in the annual rate of farmland conversion, coincident with a downturn in the economy in 1981. It is therefore difficult to determine which had the greatest impact on the reduced rate of farmland loss — **planning policies** or the **economy**. It is probable that the decline can be attributed to a combination of both factors.

As mentioned earlier, Friesen (1985) found that planning policies have been ineffective in directing residential development towards rural settlement centres. An analysis of the approved subdivisions in the RM of Tache between 1976 and 1984 also demonstrates the preference for rural residential lots over urban lots (*see* Table 3). Between 1976 and 1978, growth was directed to the existing settlement centres. Between 1979 and 1984, however, development was almost exclusively located in the rural areas.

Although the planning policies have been ineffective in directing subdivisions to the rural settlement centres, they have resulted in a significant number of subdivision application refusals. Table 4 shows the area of agricultural land that has been preserved for future agricultural use because of subdivision refusals. Since 1976, applications to subdivide have been

Table 3
Urban and Rural Residential Lots Approved in the RM of Tache, 1976–1984

Year	Number of Lots	
	Urban	Rural
1976	62	35
1977	351	36
1978	263	25
1979	8	25
1980*	1	16
1981	1	16
1982	1	18
1983	0	13
1984	1	6
Total	688	190

* Establishment of Provincial Land Use Policies

refused for nearly 3 400 ha of agricultural land. Without the planning documents, many of these applications would have been approved. Furthermore, the presence of the policies has probably reduced the number of subdivision applications, although this is impossible to quantify. The various planning instruments have, therefore, been somewhat successful in preventing the conversion of large areas of prime agricultural land.

COSTS OF DEVELOPMENT

The increase in rural residential development on Manitoba's prime agricultural lands has had a number of direct and indirect costs. These costs have been borne by all segments of rural society, not just by the farming community. The demand for **rural services** has placed a strain on municipal funds. The belief that more development results in more profit for the municipality is usually shattered when expenditures for road maintenance and improvements rise. Taxation increases, subsequent to development, have been particularly hard on the farming community because of the large land areas involved in commercial farming today.

Farmers have also had to pay the cost of **increased land values**. Rodd (1976) found that the demand for very small properties by rural residential owners increases the market value of farmland. Prices are such that farmers cannot compete for the use of such land. Many farmers have also had to alter their farming practices. Those who spread manure on their fields risk the wrath of their non-farm neighbours. Crop spraying has become increasingly hazardous. Complaints and lawsuits are becoming more common.

The conversion of 3 018 ha of farmland into non-farm uses between 1976 and 1984 has resulted in an agricultural revenue loss of approximately $1 million annually due to **lost productivity**. This generation and those in the future will continue to pay this annual cost. In most cases, such costs can be avoided. By locating rural residential development in non-agricultural areas, the loss of prime farmland may be avoided and many of the benefits that rural residential owners provide to the communities can still be achieved. The goal, therefore, is to direct rural residential growth to these areas.

Table 4
Area of Agricultural Land Maintained Through Subdivision Application Refusals, Winnipeg Region, 1976–1984[1]

Year	Rural Municipality (ha)									Total (ha)
	Brokenhead	Hanover	Ritchot	Rockwood	Rosser	St. Andrews	St. Clements	Springfield	Tache	
1976	44	72	12	NA	NA	NA	NA	104	36	268*
1977	10	121	26	NA	NA	NA	NA	305	70	532*
1978	37	28	26	111	0	24	67	285	152	730
1979	32	71	57	133	0	8	17	183	39	540
1980	21	47	6	79	0	27	81	79	70	410
1981	20	53	18	35	2	17	24	24	17	210
1982	64	2	47	48	88	23	32	0	58	362
1983	0	2	15	50	2	13	19	18	24	143
1984	1	0	8	104	1	5	4	75	2	200
Total	229	396	215	560**	93**	117**	244**	1073	468	3395

[1] Excluding Winnipeg Additional Zone
* Incomplete data for year
** Incomplete data for municipality
NA Not available

CONCLUSIONS

The rural municipalities in the Winnipeg Region have seen a tremendous growth of rural residential development during the 1970s and early 1980s. Although provincial and local planning policies are in effect, over 3 000 ha of agricultural land have been subdivided for non-farm uses. This loss of farmland has had a number of negative effects on the agricultural community. A stricter adherence to sound land-use policies could have avoided most of the negative impacts associated with rural residential development.

The planning policies now in effect in the Winnipeg Region were developed to strengthen the rural settlement centres and to direct rural residential development to less productive areas. While the policies have failed to strengthen the settlement centres, they have been partially successful in reducing the impact on the agricultural industry. The present challenge faced by planning officials is to find ways to strengthen the current policies so that future agricultural land losses can be minimized.

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Response from the audience:

Alistair Crerar: How real is the subdivision of agricultural land for agricultural purposes? How much of that land is actually used for commercial agricultural uses?

Bruce MacLean: Most of the land is used for commercial agricultural purposes. However, the figures do not tell who owns the land. Much of it is owned by horse farmers or non-farmers who rent their land to farmers.

The policies permit the subdivision of 80 acres into two 40 acre parcels for agricultural purposes, regardless of zoning. Many such splits are family-oriented. For example, a farmer may wish to give land to his son to start a farming operation. This often occurred in the RM of Hanover.

Neil Seely: Is the land that is being subdivided primarily in blocks where a farmer is changing his occupation, or is it indiscriminate ribbon development?

Bruce MacLean: It is mainly indiscriminate ribbon development. For example, a 40 acre parcel of land may be subdivided into two 20 acre parcels for family members assisting on the farm. Then, each of the two 20 acre parcels will get split into two 10 acre parcels, etc. Many of the initial subdivisions of smaller parcels were created for family splits. Presently, zoning authorities view this type of subdivided section as a loss to agriculture, and classify it rural residential. Thus, this initial subdivision pattern, usually initiated before 1976 when there were no controls, has contributed to the re-zoning of large areas of agricultural land as rural residential. In the RM of Hanover, large areas are being re-zoned, although there are hog operations in each area. The family subdivision is the culprit.

THE ROLE OF LAND-USE CHANGE IN THE MANAGEMENT OF THE NIAGARA ESCARPMENT

George McKibbon

Land-use monitoring techniques are applied to assess land-use and vegetation change within the Craigleith-Camperdown secondary planning area of Collingwood Township, Grey County, Ontario. Results of the analysis of air photos taken between 1938 and 1983 are discussed. The paper concludes that these monitoring techniques are a useful supplement to other data in interpreting change for planning purposes.

INTRODUCTION

The purpose of the *Niagara Escarpment Planning and Development Act* (1973), "is to provide for the maintenance of the Niagara Escarpment and land in its vicinity substantially as a continuous natural environment, and to ensure only such development occurs as is compatible with that natural environment." The **Niagara Escarpment Plan**, which was prepared by the Niagara Escarpment Commission to achieve that goal, was approved in June 1985 by the Province of Ontario.

Section 17 of the Act provides for a five-year review of the Plan. This pilot study on a small but critical portion of the Niagara Escarpment is an attempt to assess the usefulness of land-use monitoring techniques in evaluating the Niagara Escarpment Plan's effectiveness. In addition, the technique's usefulness in providing a basis for planning in a rural municipal planning effort is considered.

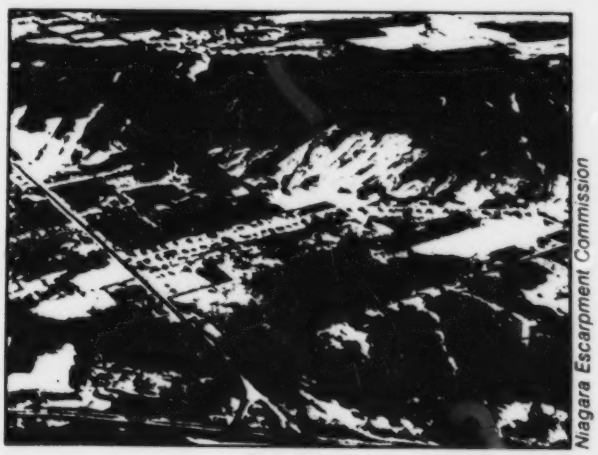
STUDY AREA

The **Craigleith-Camperdown Secondary Plan** covers a planning area that is intended to become a four-season destination resort district (*see* Figure 1). It comprises approximately 4 500 ha in the northeast corner of the Township of Collingwood. The recreation resources are based primarily on the downhill ski slopes of the Niagara Escarpment and the shoreline of Nottawasaga Bay. Chalet, resort and day-use ski development has occurred at the base of the Escarpment since the late 1940s.

The study area is composed of five basic **physiographic units**. In the offshore area, rock ledges limit recreation boating use. The shoreline itself presents a mixture of rock and sand beaches. An ancient beach ridge created during the retreat of the glaciers separates the shore plain from a middle terrace or flat plain stretching west and south from the beach ridge to the base of the Niagara Escarpment. Provincial Highway 26 parallels the shoreline below the beach ridge. The Town of Collingwood is found to the east, while Meaford and Thornbury are found to the north.

The Secondary Plan establishes the middle plateau (buffered visually by the Escarpment and beach ridge slopes) for intensive recreation development. Most of the projected 5 600 residential units for 22 500 persons will be located here. The clientele for these facilities come from Toronto and the eastern Lake Ontario urban region. The Escarpment slope exhibits a vertical drop of over 152 m, much of which can be developed for ski facilities. Above the Escarpment, the gently undulating lands are underlain by shallow soils and limestone bedrock.

The Secondary Plan, approved in 1975, has since been amended several times and the servicing provisions have been altered substantially. A review of the Secondary Plan has been initiated by the Township of Collingwood. In order to provide detailed planning input into the review, the Niagara Escarpment Commission undertook this land-use change research.



Niagara Escarpment Commission

The Niagara Escarpment, Ontario

Figure 1
Craigleith–Camperdown
Secondary Plan Area

Source: Niagara Escarpment Commission. 1983
Final Proposed Plan. County of Grey (Map 6)

METHODOLOGY

One of the objectives of the Commission's review was to provide systematic and objective data on how the land-use and vegetative patterns of the Craigleith-Camperdown area have changed over time. These data were used in conjunction with census population and employment data and a conceptual model of a recreation area development cycle describing the evolution of a tourist area from initial discovery to stagnation (Christaller, 1963). This material forms the basis from which the Niagara Escarpment Commission can make recommendations on a revised Secondary Plan.

Air photo coverage of the study area for 1938, 1966, 1974, and 1983 was analyzed using the following classification extracted from the Canada Land Use Monitoring Program classification system (Gierman, 1981):

1. Forest
   a) Natural Forest (mature and immature – mixed)
   b) Plantations (mature and immature – coniferous)
2. Agriculture
   a) Orchards
   b) Improved Land (crops and pasture)
   c) Unimproved Land (rough pasture)
3. Abandoned Farmland and Vacant Land (non-forested)
4. Residential Uses (permanent and seasonal)
5. Recreation (excluding related residential and commercial uses)
6. Commercial and Industrial Uses
7. Extraction
8. Transportation and Utility Facilities

The air photo coverage varied in scale from approximately 1:10 000 (1938) to 1:50 000 (1983). The quality was uniform with the exception of the 1938 imagery, obtained from the National Air Photo Library (NAPL) in Ottawa, which was of variable although usable quality. The other coverages were available from the Ontario Ministry of Natural Resources. The photos were analyzed using a hand-held stereoscope, beginning with the 1983 photos and working backwards chronologically. The spatial units delineated on the air photos were subsequently transferred to base maps at 1:25 000 scale for each of the four periods of photography. As the 1983 land use was analyzed, field inspections were carried out to ensure proper interpretation of difficult areas.

Upon completion of the four maps, the areas within each class were calculated and totalled on an individual map sheet basis to create Table 1. The area calculations were performed using a digital planimeter (Planix 7), which was found to have certain operating characteristics that affected the results. Adjustments were made accordingly. Overall, the maximum error generated by the measurement process is approximately 5%. This level of error applies to the calculations for 1974 and 1983 where the land-use units were relatively small. The level of error was less for 1938 and 1966 as the land-use units were larger.

improved land) each covered more than 1 630 ha. In 1966 and 1974, both declined with corresponding increases in land dedicated to residential and recreation uses. In 1983, natural forest cover rose to a level exceeding that of 1938 due to land reverting from agricultural use. Most of these lands are awaiting services and eventual development.

Viable recreation land uses rely on high landscape quality and visual amenity. It is clear from the changes recorded that substantial landscape alterations have occurred over the years. Therefore, policies of the Secondary Plan dealing with visual and landscape amenity require careful attention. In particular, the beach ridge and Escarpment slopes are identified as being critical to landscape quality. Between 1938 and 1983, forest cover was removed from these landforms, thereby reducing their effectiveness as a visual buffer.

The traditional landscape pattern in 1938 was characterized by small fields, hedgerows, and farm buildings scattered throughout the study area. This pattern covered 1 630 ha in 1938 and 529 ha in 1983 (primarily above and west of the Escarpment brow). This transition represents a substantial qualitative change which could contribute to the decline of a

Table 1
Craigleith-Camperdown Area
Vegetation and Land-Use Change, 1938–1983[1]

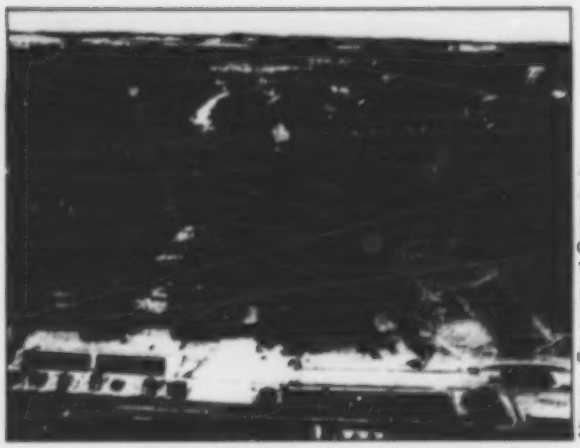
Land Use and Vegetation Class	1938		1966		1974		1983	
	ha	%	ha	%	ha	%	ha	%
Natural Forest	1 635	37	1 534	34	1 251	28	1 808	41
Plantations	0	0	46	1	48	1	80	2
Orchards	71	2	36	1	28	1	33	1
Improved Agricultural Land	1 630	37	1 223	27	975	22	529	12
Unimproved Agricultural Land	705	16	263	6	316	7	308	7
Abandoned/Vacant Land	439	10	935	21	1 052	24	1 049	24
Residential	13	0	234	5	384	9	395	9
Recreation	0	0	199	4	296	7	322	7
Commercial and Industrial	0	0	16	0	28	1	51	1
Extraction	0	0	2	0	6	0	6	0
Transportation and Utility	0	0	8	0	11	0	25	1
Total	4 500	100	4 500	100	4 500	100	4 500	100

[1] Numbers in table have not been corrected to take account of 5% error factor

RESULTS

First, a transformation in the overall structure of land-use and vegetation patterns between 1938 and 1983 was observed (*see* Table 1). For 1938, the land-use and vegetation pattern was divided into six classes. In 1966, more than eight categories existed; more became evident in 1974 and 1983. The 1938 data depicts conditions prior to recreation development when the two largest categories of land (natural forest and

recreation area. Some apple orchard development had occurred on the middle terrace by 1938. It is reasonable to expect that this activity would have continued and expanded, however, recreation development has resulted in the displacement of orchards from lands at the Escarpment base. The transition from an agricultural to a recreation-based community is now essentially complete.



Niagara Escarpment Commission

Niagara Escarpment ski development, Ontario

CONCLUSIONS

Land-use monitoring techniques applied within this study produced useful and interesting results. Substantial land-use and vegetation changes have occurred. By highlighting these changes in a systematic manner, understandable to both township residents and planners alike, planning can be effective in dealing with the implications.

Two implications for the Secondary Plan can be directly related to this research. First, increased effort is required to keep buildings not associated with ski facilities off the Escarpment slope. Furthermore, more effort is needed to maintain forest cover on both the Escarpment and beachridge slopes. Second, provisions within the Secondary Plan for large, open recreation areas interspersed with residential development on the middle plateau require strengthening to ensure that the development pattern is dispersed. This will ensure that development is more in keeping with the rural landscape pattern which existed in 1938. In addition, the research provides background for population and employment analysis required to update the Secondary Plan.

Limitations of the land-use change data exist. They cannot be applied usefully in isolation, but have to be interpreted in conjunction with other socio-economic data. In this evaluation, census population and employment data were used within the context of a recreation area development model. Second, land-use change monitoring is normally carried out at a scale in excess of 1:50 000 while local planning is carried out at scales of 1:25 000 or less. Monitoring techniques need to be adapted to the larger scale requirements to be useful for municipal planning. As with the analysis of landscape quality, when the level of detail moves from a macro to a micro level, the analysis needs to be adjusted accordingly. One useful change might be to include a three dimensional consideration of landscape views.

The analysis used in this study could have been supplemented by a computer-assisted mapping system. This would have allowed the data to be correlated to each of the five physiographic land units which make up the study area. The ease with which these calculations could be carried out on a computer would have greatly expanded the usefulness of the study.

> "Change and recurrence are the sense of being alive — things gone by, death to come, and present awareness. The world around us, so much of it our own creation, shifts continually and often bewilders us. We reach out to the world to preserve or to change it and so to make our desires visible. The arguments of planning all come down to the management of change" (Lynch, 1962).

This paper has discussed the evidence of change contained in an analysis of air photography taken between 1938 and 1983 in the Craigleith-Camperdown area. It has also documented how these changes might be evaluated to determine the fit between planning expectations for a landscape and what presently exists.

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THE CONTRIBUTION OF REGIONAL COUNTY MUNICIPALITIES TO LAND MANAGEMENT AND LAND-USE ZONING IN QUEBEC

Fernand Martin

Introduced under the provisions of the Land Use Planning and Development Act (1979), the Regional County Municipality (RCM) contributes to land management and land-use control in Quebec. This paper reviews the principles underlying the Land Use Planning and Development Act, and provides an overview of the creation of the 95 RCMs as well as the responsibility of each for the adoption and implementation of a management plan.

INTRODUCTION

Over the past 25 years, Quebec has undergone a far-reaching reform of government administration. Education, health, and social security were among the first sectors to be affected by the change. Reforms initiated were designed to improve both the quality of, and access to, public services. During the past seven years, the municipal affairs sector has undergone significant reforms with regard to land development and urban planning, municipal taxation, and municipal democracy. The Province of Quebec has been pursuing a fundamental objective in proposing these municipal reforms. That objective was and still is to enhance the powers of local authorities.

The purpose of this paper is to discuss the ways the **Regional County Municipalities** (RCM), set up under the provisions of the *Land Use Planning and Development Act* (1979), contribute to land management and land-use control in Quebec.

THE REGIONAL COUNTY MUNICIPALITY

The Government of Quebec created 95 RCMs to replace the 71 county corporations that had existed until the adoption of the *Land Use Planning and Development Act*. In addition to assuming the responsibilities of the county councils, the RCMs were entrusted with a task of primary importance — preparing and reviewing the management plans. The Montreal and Quebec urban communities and the Outaouais Regional Community, all created prior to adoption of the *Land Use Planning and Development Act*, play a role identical to that of an RCM with regard to land management.

The RCMs and the urban and regional communities cover most of the land area of Quebec. The only areas in which no RCM exists are those located north of the 55th parallel, the land described in the Annex to the *James Bay Region Development Act* (1971), and the land administered by the Lower North Shore Municipality along the St. Lawrence River. The RCMs include the urban and rural municipalities of a single region and may also include land not part of a municipality. With the exception of the urban and regional communities, the RCMs on the average comprise 14 municipalities including two towns. The smallest RCM has an area of 182 km^2 whereas the largest has an area of 66 992 km^2. The average population is 33 000, the lowest population being 6 090 and the highest 262 300.

Depending on the number of representatives and the form of representation agreed upon by the member-municipalities of each RCM, the council is made up of the mayor of each member-municipality and other municipal council representatives. The Chairman, the head of the RCM council, is elected from among the mayors for a term of two years.

The RCM is not a regional government. Its officers are not elected and it does not have its own means of financing. It is financed by government subsidies for matters related to planning and development and on a shared basis by the member-municipalities for all other areas of activity. As mentioned earlier, the primary mission of RCMs is land-use planning but they also have a role in property assessment; bridge, road, and waterway maintenance; and the management of lands not part of a municipality. In terms of land-use planning, all RCMs are required to adopt a management plan for their respective territories by December 12, 1986.

PRINCIPLES OF THE LAND USE PLANNING AND DEVELOPMENT ACT

The *Land Use Planning and Development Act* (1979) is based on four principles:

- Land-use planning is a political responsibility, not simply a technical or administrative matter. Politicians in the Government of Quebec and at the local level must consult each other to make final decisions regarding changes that will be made to the environment.
- People must, through a mechanism of information and consultation, be involved in the various stages of defining and revising the instruments for planning. This depends not only on actively involved citizens, but also on responsible, elected officials to foster the participation of all concerned parties in the area.
- Planning is shared between the various decision-making levels (provincial government, RCM, local municipalities) and each level has its own area of responsibility.
- All decision-making levels must consult each other and coordinate their actions.

Land planning in Quebec is both an ongoing process calling for the exchange of opinions between regional or local municipalities and interested parties in the area, and a process of mutual consultation between politicians with specific responsibilities at various decision-making levels. The management plan of an individual RCM, moreover, appears to be an especially appropriate framework for consultation between the parties concerned in the local municipality, the RCM, and the Government of Quebec.

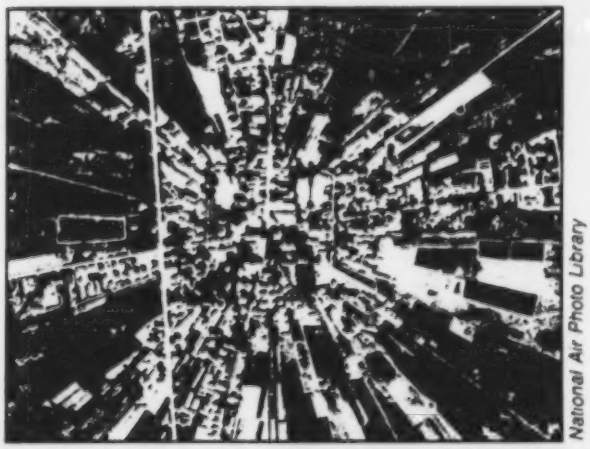
PREPARING THE MANAGEMENT PLAN

The procedure used for the preparation of management plans provides a good illustration of the importance the provincial government attaches to exchanges between local municipalities, RCMs, and government officials (*see* Figure 1). The RCM initiates the procedure with a period of mutual information exchange for the parties concerned by adopting a resolution announcing its intent to prepare a management plan. The Government of Quebec is then obliged to send to the RCM a notice describing its preliminary management aims, plans for infrastructures, public services, and any development it intends to implement. The municipalities are also obliged to submit to the RCM a copy of all urban planning documents in their possession. This period of mutual information exchange concludes when the RCM adopts a **preliminary planning proposal**.

The second phase is the consultation and conciliation phase which begins when the RCM submits its preliminary planning proposal to the local municipalities for consultation. This consultation permits the RCM to adopt a **planning proposal** for submission to the provincial government. Within 90 days of receiving the planning proposal, the province informs the RCM of the development and management projects it intends to implement which will affect the proposal. It also documents any objections it may have to the proposal.

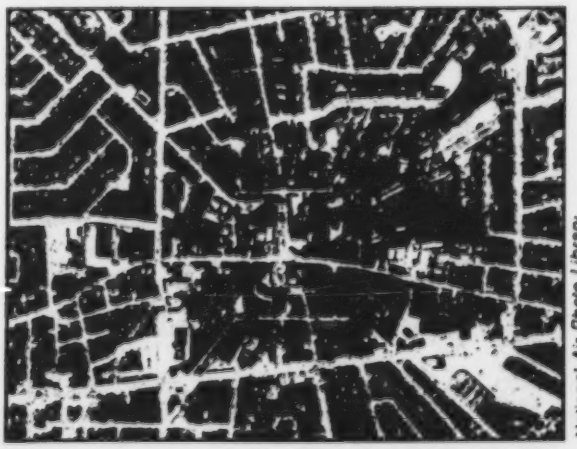
A third information and consultation period begins with the adoption by the RCM of the final version of its management plan. During this period, the RCM prepares an abstract of the final version for distribution to the public, organizes public information and consultation meetings, and adopts its **management plan**. Once the RCM plan is in effect, the Government of Quebec and the local municipalities are bound to comply with the provisions of the management plan.

The *Land Use Planning and Development Act*, by virtue of its objectives and the mechanisms for planning it has introduced, decentralizes land planning and management. The provincial government has decided not to prepare an overall management plan for Quebec. Instead, it will participate as a partner in the preparation of management plans for each RCM. In essence, this is the originality and challenge of the Quebec approach to land planning and management.



National Air Photo Library

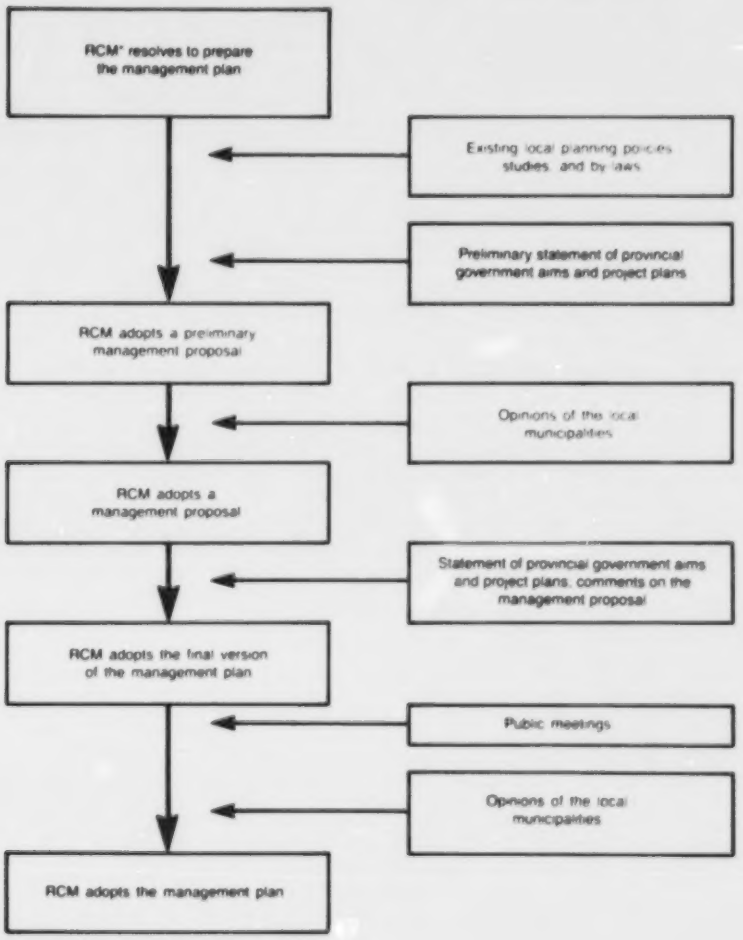
Charlesbourg, Quebec 1950



National Air Photo Library

Charlesbourg, Quebec 1981

Figure 1
The Regional Planning Process, Province of Quebec


RCM* resolves to prepare the management plan
Existing local planning policies, studies, and by-laws
Preliminary statement of provincial government aims and project plans
RCM adopts a preliminary management proposal
Opinions of the local municipalities
RCM adopts a management proposal
Statement of provincial government aims and project plans, comments on the management proposal
RCM adopts the final version of the management plan
Public meetings
Opinions of the local municipalities
RCM adopts the management plan

* Regional County Municipality

CONTENTS OF THE MANAGEMENT PLAN

A management plan contains a number of obligatory and optional elements. An outline of the compulsory elements is given below:

- the general aims of the land-management plan;
- the general policies on land use for the entire territory of the RCM;
- the delineation of the urban perimeters;
- the identification of zones where land occupation is subject to special constraints for reasons of public safety, such as flooding, erosion, landslide, etc.;
- the identification of areas that are of historical, cultural, aesthetic, or ecological interest;
- the identification, approximate location and, where applicable, the schedule for public service and infrastructure developments which the RCM considers to be intermunicipal in nature;
- the identification and approximate location of the public services and infrastructure to be established by the provincial government, its departments, and agencies, as well as by public bodies and school corporations; and
- the identification and approximate location of the major electricity, gas, telecommunications, and cable delivery networks.

The management plan must also be accompanied by the following documents:

- a complementary document on the minimum standards to be included in the zoning and subdivision by-laws adopted by the municipalities;
- a document indicating the approximate cost of the various intermunicipal public services and infrastructures proposed in the plan; and

- a document summarizing the methods employed and conclusions drawn from the public hearings held during preparation of the management plan.

CONTRIBUTION OF THE REGIONAL COUNTY MUNICIPALITIES TO LAND MANAGEMENT

The nature of the planning process established under the *Land Use Planning and Development Act*, together with the creation of the RCMs, has contributed to improving both the level of knowledge of land use and the quality of land-use control at local and provincial levels. At the local level, most mayors on the RCM council quickly understood that the *Land Use Planning and Development Act*, which grouped them together into RCMs, gave them significant political power. In addition, the Act provided an official channel through which expectations regarding land use, and inconsistencies of policy and practice, could be brought to the attention of the provincial government. Consequently, the 95 RCMs of Quebec are preparing their respective management plans, each having reached various stages of progress.

At the provincial government level, the creation of the RCMs has changed the province's manner of operating. The government for the first time is committed to state its aims and outline its plans with respect to the land base of the RCMs. The *Land Use Planning and Development Act* also provides that future government activities will be bound by the management plans. As a result, provincial departments have had to complete their studies and surveys more rapidly in order to meet RCM consultation schedules. In addition, accessibility to existing data has improved. The Government of Quebec has created interdepartmental committees to better consolidate the aims and practices of the departments. For example, interdepartmental committees to define the provincial government position on the development of shorelines, minimum standards, and management of public lands have been established. Legislative amendments to Acts relating to land management have also been introduced to ensure conformity to the spirit of the *Land Use Planning and Development Act*. The *Act to Preserve Agricultural Land* (1978), for example, was amended to ensure consistency between it and the *Land Use Planning and Development Act*. Finally, the Departments of Energy and Resources; Recreation, Fish and Game; Agriculture; and Environment have established plans for the use of public lands in the 44 RCMs with public lands within their boundaries.

The quality of land-use control can only improve as a result of the establishment of the RCMs. The procedure used for plan preparation calls for the exchange of information and consultation. Therefore, the process has a very good chance of attracting the support of interested parties who will thereafter want to ensure that the policy aims and objectives included in the management plan are respected. The RCM, under the provisions of the Act, must review its management plan every five years. Thus, it will be in a position to make a periodic evaluation of the suitability and currency of the plan and to adjust the policies and control mechanisms accordingly.

SUMMARY

It would be misleading to give the impression that the preparation of the management plans by the RCMs has not created adjustment problems at both provincial or local levels. The provincial departments and the RCMs have had to learn to come to terms with the planning procedures introduced by the *Land Use Planning and Development Act*, to exchange information with each other, and to coordinate their activities. Moreover, it would be unrealistic to believe that these problems will shortly disappear. The planning procedure established by the *Land Use Planning and Development Act* has established a channel of communication in which differences of opinions and values of those involved are quickly exposed. This, in itself, has created a climate appropriate for positive goal definition and problem resolution.

Generally, RCM activities are viewed positively by both the provincial and local governments. Recently, the Quebec Minister of Municipal Affairs declared that the RCMs are here to stay. Furthermore, a study has just been initiated to study additional areas of responsibility and financial resourcing of RCMs in the future. This study should provoke a lively debate over the next year between the provincial government and the Quebec municipal world.

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Response from the audience:

Michel Melançon: You have elaborated on the content of the management plan. Would it be possible to specify what kind of information is required by the RCMs to complete their management plans?

Fernand Martin: A number of steps are involved in creating a management plan. First, the local municipalities provide the RCM with the existing zoning by-laws and management plans. As well, the provincial government provides the RCM with information regarding the projects which it intends to implement in each RCM in the following year, and the policies which they are expected to follow. These include the policy on floodplain management, the preservation of agricultural land, and a proposed plan for public lands. All of these serve as a guideline for management plan creation. Consultation between the RCM and the provincial government is necessary to complete a management plan which is mutually agreeable to both parties. It is also important to remember that these management plans are aimed at the regional scale with groups such as the union of agricultural producers, forest producers, and recreationists generally being most interested in contributing to the management-plan process.

A SUMMARY OF THE RECENT CHANGE DETECTION PROJECTS CARRIED OUT IN NEW BRUNSWICK[1]

Eugene Derenyi, Michael Dillon, Lawrence Peters[2], and Douglas Morgan

Four principal projects completed in New Brunswick as part of the Remote Sensing Technology Enhancement Program (TEP) are presented. The projects cover application areas where monitoring changes, through the use of spaceborne data, can facilitate the efficient management of land resources in New Brunswick — in crop rotation monitoring, forest cutover mapping, change detection in watersheds, and snow cover mapping for flood forecasting in the Saint John River Valley. Each change detection problem is unique and hence, the methodologies and solutions must be adapted to local conditions and information requirements. The advantages of using spaceborne sensing over conventional techniques are demonstrated, with the expectation that remote sensing technology will be an increasingly important tool for land-resource change monitoring.

INTRODUCTION

Monitoring environmental change is the most successful application of spaceborne sensor data in the Province of New Brunswick. While the land area occupied by the province is rather small by Canadian standards, a variety of land cover types are represented. Farm fields are irregular in size, shape, and orientation and are, in places, pockets within the forest expanse. The forest is composed mainly of softwood stands which are frequently interspersed with hardwoods and mixed woods. Although much of the forest land remains in large Crown or industry owned holdings, small private woodlots are not uncommon. Therefore, the spatial resolution of currently operational spaceborne sensors is inadequate for collecting initial environmental inventories. It is, however, most useful for the subsequent identification of changes.

Over the years various methods for monitoring environmental parameters have been developed and successfully tested by several Canadian agencies and some have advanced from the research to the operational stage. An excellent documentation of this appears in Thompson (1982) and in the references cited therein. There is no guarantee, however, that a particular methodology which functions satisfactorily in one region will perform equally well in another. Therefore, in April 1983, a Memorandum of Understanding was signed by Energy, Mines and Resources Canada and the Council of Maritime Premiers to institute a **Remote Sensing Technology Enhancement Program** (TEP). Under this agreement, the Canada Centre for Remote Sensing provides assistance to provincial agencies in adopting remote sensing technologies. The four principal projects completed in New Brunswick as a part of this program are summarized in this paper. Analysis for the first three projects was performed using the ARIES II digital image analysis system (Dipix Systems Ltd.) at the Department of Surveying Engineering, University of New Brunswick.

CROP ROTATION MONITORING

Soil erosion by water on agricultural cropland in the Saint John River Valley is a serious problem, resulting in reduced crop productivity and contributing to water pollution. Soil conservationists predict long term annual soil loss values using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). One of the six parameters in this equation is crop management, denoted "C". C values for permanent pasture, potato grain rotation, and continuous potato cropping are 0.003, 0.32, and 0.53 respectively. Therefore, annual monitoring of crop rotation practices is a vital element in the management of agricultural resources. To accomplish this monitoring task, digital analysis of LANDSAT Multispectral Scanner (MSS) data provides a less costly method than ground or aerial survey.

[1]The authors wish to acknowledge the technical assistance provided by the CCRS Technology Enhancement Office. Jennifer Brown and Elizabeth Dillon performed the image analysis for the forestry and agricultural projects respectively. Mary Dwyer-Rigby organized the Snow Cover Mapping projects.

[2]Lawrence Peters presented the paper at the Workshop.

The objective of the first project (sponsored by the New Brunswick Department of Agriculture and Rural Development) was to classify the type of crops grown in individual farm fields during a four year period (1979-1982), and thereby gain information on crop rotation practices. Potato, grain, and hay were classified. Grand Falls and vicinity (in the Saint John River Valley) was selected as the project site. Geometrically corrected (DICS) LANDSAT MSS data were available for: August 4, 1979; August 17, 1980; July 25, 1981; and August 16, 1982.

A standard procedure for crop rotation monitoring involves delineating crop types in subsequent growing seasons using a supervised classification, generating area estimates for each crop over predetermined geographic units, and producing colour or gray scale plots of the classification. A visual comparison of results from subsequent years yields the crop management information. Although the above procedure was followed in general, two important refinements were introduced to suit local conditions and to increase operational efficiency.

It is most desirable to secure field-specific information on crop rotation for soil conservation purposes. Crop-area statistics obtained by pixel counts cannot provide such information and a visual comparison of thematic plots of the classifications for individual years is a tedious job. Therefore, a theme classification was performed by the ARIES II on the "four band theme image file" to ascertain the sequence of rotating potato crop with other crops in individual farm fields (Derenyi and Yazdani, 1984). Fifteen possible combinations were generated. A more concise summary was produced by classifying fields according to the number of years potatoes were grown during the four-year study period. The results revealed that potatoes were grown in all four years in approximately 3% of the fields classified, while 15% of the fields grew potatoes in three years, and 36% grew potatoes in two years. Potatoes were grown in only one year in 64% of the farm fields.

The results were found to be satisfactory when spot-checked against data collected by field survey. Since aggregate crop-area estimates were not needed, classification accuracy checks, by comparing the area estimates for the themes with reference data, were not performed. The aim was to demonstrate that the type of crops grown in individual fields can be identified consistently. This was achieved with satisfactory results.

Analysis of LANDSAT MSS data in this manner is a quick and cost-effective way to monitor crop rotation in regions with small, irregularly shaped farm fields. Regarding temporal aspects of the data, mid-August imagery is preferred.

FOREST CUTOVER MAPPING

The New Brunswick Department of Natural Resources (NBDNR) requires annual information on tree harvesting in the province in order to maintain a current forest inventory. Presently, such information is obtained by the interpretation of aerial photographs. This is a lengthy process and the updating often lags up to one year behind. Furthermore, no information on private woodlots and free-hold lands is compiled.

Studies conducted elsewhere (Banner and Lynham, 1981) indicate that the problem can be alleviated by digital analysis of LANDSAT MSS data. Therefore, this subject was selected as one of the TEP projects. The objective was to test, under New Brunswick conditions, the performance of an existing digital image analysis method for annual or periodic monitoring of changes in forest cover due to tree harvesting operations.

Two test sites, one in the north-central, the other in the south-central region of the province were selected. Each had an areal coverage equivalent to four 1:50 000 NTS map sheets. Four DICS data tapes dated October 9, 1975; October 12, 1976; September 23, 1978; and September 27, 1979 were available for Site 1. Two tapes, dated September 23, 1978 and September 27, 1979, were available for Site 2.

A multi-temporal colour composite of Band 5 data was displayed on the monitor. The red colour-gun was used to indicate data from the most recent year while the blue and green guns were used for the earlier years. Forest canopy has low reflectance in the red band, while bare ground exposed by a harvesting operation is a good reflector. Consequently, all areas where clear-cutting occurred in the interim period emerged as bright red. A supervised classification was then performed to sort the cuts into individual years and to create a permanent digital file. The entire four-year data set for Site 1 was successfully processed in one batch. This demonstrates the possibility of separating themes and analyzing specific years from multi-year data sets in one operation, provided that suitable ground reference data are available.

The results of the classification were verified against the NBDNR forest inventory maps and generally were judged to be satisfactory, thereby proving the applicability of this methodology in New Brunswick. However, during the verification process small clusters of pixels were detected which were misclassified as cutover areas. Misregistration of the Band 5 multi-temporal overlays, and changes which were not cutover but showed similar spectral signatures, accounted for the inaccuracy. Errors of commission of this type can be compensated for by regression analysis when only aggregate cutover area estimates are needed. However, the aim in this study was to map individual clear-cuts as accurately as possible. Post-classification filtering risked the omission of small legitimate cuts prevalent on private woodlots. Therefore, an interactive editing routine was devised in which the analyst deleted misclassified pixels based on obvious signs of misregistration and on associated features, including proximity to settled or agricultural areas, absence of forest roads, and terrain and vegetation-cover conditions which could not support forest. Although a time-consuming process, this operation improved the results significantly.

This project demonstrated that forest clear-cuts can be successfully classified and mapped, on both Crown and free-hold lands in the Province of New Brunswick, using digital image analysis of LANDSAT MSS data. Cuts of two to three hectares and larger can be detected consistently. The procedure followed is not automatic and the skill of the analyst is a key element to its success.

CHANGE DETECTION IN WATERSHEDS

As cultural activities and resource development in watersheds that supply drinking water to New Brunswick communities increases, it is feared that the water quality will be degraded. In time, this could lead to additional water treatment costs. The Water Resources Branch of the New Brunswick Department of the Environment is responsible for managing the water resources of the province and minimizing the impact of development on the water supply. Therefore, it is important to monitor the rate and type of development that occurs in the watersheds throughout the province. Spaceborne sensors could be of assistance in this effort.

The objective of this project was to assess the effectiveness of LANDSAT MSS data to detect significant changes within a number of watersheds in southern New Brunswick. Development (subdivision, land tenure, roads) in New Brunswick occurs on a relatively small scale and has tended to be diffuse, making the interpretation of LANDSAT data more difficult than in Western Canada.

For this paper, the Irishtown watershed area, about 6 km north of Moncton, was selected for discussion. This watershed has mainly forest and farm land, with a limited amount of ribbon housing-development along the highways which pass through the river basin. Development inside the watershed over the study period has been limited to individual houses with small amounts of clearing and grubbing. In close proximity to the watershed, an industrial park area has been growing rapidly and a number of new subdivisions have been built. This development is moving north toward the watershed boundary and recently, there has been increased activity inside the watershed area itself.

DICS LANDSAT MSS data were available for July 14, 1974; June 30, 1975; July 29, 1978; and July 15, 1979; while aerial photographs were available for October 1970, September October 1975, July 1977, and August 1982. A number of standard methods of multi-temporal analysis were considered including an overlay of Band 5 images for sequential years and a similar overlay of the biomass ratio. After some experimentation, it was found that the following method was most useful in detecting significant changes. Other methods proved either too global in their detection of change, or were found to be insensitive.

1. A biomass ratio was generated over the area of interest as:

   $$B = K \frac{MSS7}{MSS5}$$

   where B is the biomass ratio, MSS7 and MSS5 are band 7 and 5 spectral response values respectively, and K is a constant.

2. The gradient of the biomass ratio was obtained over the study period by the formula:

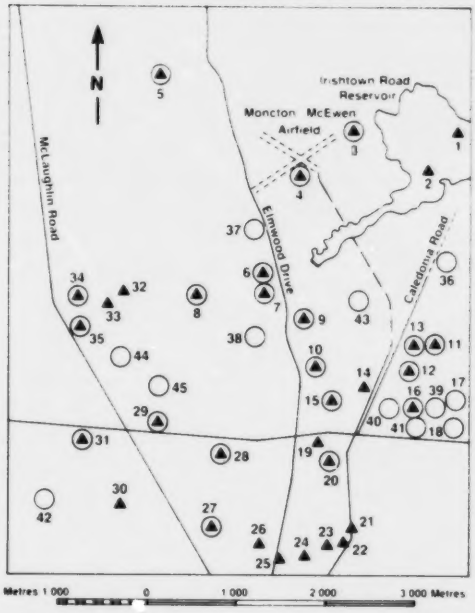
   $$GRAD\ (T_1 - T_2) = K * B(T_1)/B(T_2)$$

3. A theme file of the high gradient pixels was created using the parallelepiped classification routine.

In order to assess the method, changes detected by the use of LANDSAT data for the 1975-1979 period were compared with changes that were detected on aerial photographs. Difficulties were found in determining exactly when a change started and was completed. Road development, for example, takes several years. Changes of this type which span the study period may or may not be classified as a change depending on the time interval selected. Similarly, areas of change detected by either method depended on the level of activity on the site, the amount of vegetation that was removed, and on surface characteristics at the time of imaging. In this case, the approximate area of change was identified and the centroid of the changing area was plotted. Figure 1 shows the location of these areas.

Of the 48 changes detected, 25 (52%) were classed as matches, 13 (27%) were errors of commission, and 10 (21%) were errors of omission. Due to differences in resolution between the two methods, a single change delineated by the analysis of the LANDSAT data sometimes corresponded to a cluster of changes found on the aerial photographs. Where this occurred, the two methods were considered to match. For example, in Figure 1, point 16 includes three areas of change identified by aerial photographic means; these are identified as a single area on the satellite image. Such matches represent the most significant changes that occurred in the test area.

Figure 1
Comparison of Changes Detected by Digital Analysis of LANDSAT Data and Aerial Photography (1975–1979)



▲ Change detected by LANDSAT analysis only

◯ Change detected by photography only

◉ Change detected by both LANDSAT analysis and photography

The errors of commission included those changes that were flagged as changes in the digital analysis but could not be confirmed satisfactorily by aerial photographic means. This occurred most often with changes in water bodies possibly due to variations in illumination, water level, or the presence/absence of vegetation in the shallows. Errors of omission were those changes which were identified on the aerial photographs but were too small to be identified by the LANDSAT analysis. Typically, these included small forest clear-cuts (one to two pixels in size), individual house construction, and gravel pit expansion. Such changes were of little significance regarding the utility of the method.

This type of analysis provides a quick, cost-effective way of monitoring watersheds in New Brunswick, as well as in other parts of Eastern Canada where small scale developments are the norm, and where traditional classification techniques are difficult if not impossible to use. Appropriately applied, the LANDSAT analysis could provide ground survey personnel with a map of potential changes such that a more detailed assessment could then be made by traditional methods.

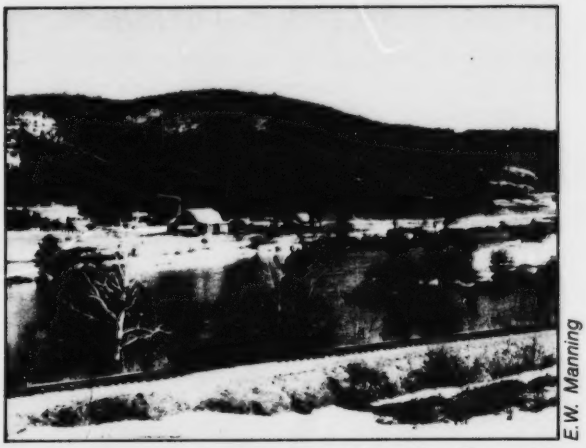
For small areas, such as the Irishtown watershed, the cost of each method of analysis is similar. However, for larger areas the cost of the digital method is only 1/10 of traditional aerial photo-interpretation costs. For the Irishtown area, the cost of the digital analysis was approximately $500.

Several advantages are offered by the digital analysis technique which cannot be provided by the aerial photographic method. These are speed, objectivity, and the relative insensitivity of cost to the size of the area. Less obvious benefits include the ability to see the progress of development over time and to monitor the activity more often without the need for special flights or ground surveys. Several disadvantages are also apparent. Beyond the actual detection of change, the information provided by digital analysis has limited use due to difficulties of discriminating between the different kinds of change. For example, the similarity of the spectral signature between gravel pits and subdivision development make it almost impossible to distinguish between them. Therefore, it is more appropriate to verify the **nature** of the change by ground inspection or air survey.

NEAR REAL-TIME SNOW COVER MAPPING

The presence and extent of snow cover during late winter and early spring is an integral component of flood forecasting models. Local implementation of accurate, cost-effective snow cover assessment and mapping for the Saint John River Basin on a near real-time basis has been needed for a long time.

The results of three methods of snow-cover assessment and mapping can, at present, be used by the Flood Forecast Centre. For the past few years, snow cover in the Saint John River Basin has been assessed in the United States by the National Environmental Satellite Service (NESS) in Washington, D.C., and in Canada by the Atmospheric Environment Service (AES) in Downsview, Ontario. The former provided their assessment from a visual interpretation of photographic images of Thermal Infra-Red Satellite/National Oceanic and Atmospheric Administration (TIROS/NOAA) satellite data, while the latter, until 1981, performed only computer-aided analysis of digital data from the same satellites. During the winter of 1981/82, AES personnel devised a less expensive, yet seemingly accurate, method of interpretation through the analysis of photographic prints on the Linear Measuring Set (LMS) System.



E.W. Manning

Saint John River Valley, New Brunswick

The objective of the project was to implement, at the local level, a method developed at AES for monitoring snow cover, on a near real-time basis for the Saint John River Basin, during the spring melt period. The project was undertaken by Trainor Surveys (1974) Ltd. in Fredericton, New Brunswick. AES software was installed in the LMS System of the company in early March, 1983 and a total of 10 images were analyzed during the springs of 1983 and 1984 as follows: March 25 and 26, April 10, 13, and 19 in 1983; March 26, April 3, 23, and 29, May 7 in 1984. All were photographic prints of TIROS/NOAA satellite data at a scale of 1:4 000 000.

The LMS system is an electronic "image processor". It can measure areas or distances, isolate selected characteristic gray values, and overlay scale-referenced images and maps. Any hard copy image or other data in print or transparency form can be analyzed. The instrument can also process live television pictures in real time or video cassette recorded images in still-frame mode. The main components of the instrument include the control box and processing unit, a video camera on a copy stand, a television monitor, and a video cassette recorder. A desk-top computer, a line printer, and a plotter can extend processing, storage, and display capability. The unit at Trainor Surveys has an Apple II Plus computer on line.

A geographic outline of New Brunswick, the Saint John River Basin, and all of the sub-basins had been stored on a floppy disk, and recalled to the LMS monitor at the start of the analysis. The image to be analyzed was then placed under the video camera and the zoom setting was adjusted to obtain a good match with the graphics on the screen. Next, density slicing was performed to separate snow cover from open ground. Ground-reference data were used to determine the threshold density value. "Noise" caused by clouds was edited out on the

screen with a light pen and snow signature was added where known snow cover existed beneath the clouds. Finally, the area of snow cover was calculated for the entire basin and for each sub-basin. A tabular summary of the area calculations and a snow cover map comprised the final output products.

In all cases the analysis was completed in a few hours. From AES, the NOAA images were delivered to the company overnight and the results were given to the Flood Forecast Centre on the same day. It is apparent that accurate near real-time snow cover analysis and mapping can be cost-effectively handled at the local level. The 1983 results were compared with those obtained by the digital image analysis method and were found to be compatible and fully satisfactory. However, the analysis time and costs were much lower for the AES method. Prior knowledge of the topography, vegetation, land cover and/or land use integrated with field data from snow courses and other environmental measures during the analysis, would improve the accuracy. It is anticipated that such components will be utilized increasingly in the future.

SUMMARY

The projects described in this paper cover four application areas where monitoring changes, through the use of spaceborne data, can facilitate the efficient management of land resources in New Brunswick. It has been demonstrated that each change-detection problem is unique and that each solution must be tailored to its nature and information requirements. Methodologies developed in one particular place can generally be applied successfully in other locations, but must be adapted to local conditions and requirements.

In all four projects the objectives were met and the advantages of using spaceborne sensing over conventional techniques were demonstrated. Through TEP, remote sensing has received wide exposure in New Brunswick and it is expected that the technology will become an increasingly important tool for monitoring changes related to land resources.

Eugene Derenyi is from the Survey Engineering Department, University of New Brunswick.

Michael Dillon is from the Planning and Development Division, New Brunswick Department of Agriculture and Rural Development.

Lawrence Peters is Chief, Groundwater Section, Water Resources Branch, Environment New Brunswick. He is also Chairman of the New Brunswick Remote Sensing Committee.

Douglas Morgan is from Trainor Surveys (1974) Ltd., Fredericton, N.B.

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Response from the audience:

Larry Martin: Will you please comment on other forms of higher resolution remotely-sensed information such as the Thematic Mapper (TM) or perhaps aircraft-borne sensor data. Did you consider using it in New Brunswick? Also, if you were to use it, where do you feel improvements may be gained?

Lawrence Peters: The TM was not readily available when this study was undertaken. Also, all of the data is received from the United States because of receiving station problems in Canada. Thus, we have not completed any work with TM data. However, it seems safe to say that the TM would have provided a more penetrating data source because of the smallness of the changes detectable. The work that has been accomplished can be extended easily toward TM use. Regarding the use of other sensors, funds are very restricted; hence, no others were considered due to expense. Multispectral Electro-optical Imaging System/Scanner (MEIS) data has been used experimentally by the Canadian Forestry Service (CFS) to detect changes in the forest due to insect infestation.

Harold Moore: Could you elaborate on the next step in implementing some of these techniques into operational change detection? The results look good — what is the next step?

Lawrence Peters: The next step would be to integrate these techniques into certain parts of the province's land information network. For example, watershed change-detection monitoring could be used at head offices to direct planners in their collection of information. Similarly, in the potato-rotation study, the head office could provide direction to better inform farmers of the impacts of their rotation practices.

PUBLIC PERCEPTION OF LAND-DEGRADATION ISSUES IN CANADA

Sally Rutherford

Public support is very important in policy development and fund allocation. Land-degradation issues in Canada do not have a high public profile at present. Hearings held across the country by the Standing Senate Committee on Agriculture, Fisheries and Forestry, confirmed the poor state of public awareness regarding the problem of land degradation, especially in terms of its existence as a national problem. To heighten the awareness of Canadians, the Committee wrote Soil at Risk (1984), a report directed at the general public and presented from a national perspective. The resulting media coverage and enthusiastic public response to the report are encouraging first steps towards bringing public opinion to the point of widespread support for land-degradation research.

INTRODUCTION

However peripheral public perceptions may seem to research, it is a fact of life that today **public support** is very important in the development of policy and also in the allocation of scarce research funds. With the exception of those who are directly self-interested, there is little public understanding of the issue of land degradation.

Land degradation is a fairly intangible problem to those who are unaware of what the land base provides for them. This issue does not have the kind of public profile that air pollution or acid rain does. At the recent International Symposium on Acid Rain in Muskoka, Ontario (Sept. 15-20, 1985), figures were released that showed that 95% of the Canadian and the United States population are aware of the problems induced by acid rain and would be willing to pay to control them. Unfortunately, land degradation does not have the same level of public interest at the present time.

Acid rain did not always have this kind of public interest. Dr. Harold Harvey from the University of Toronto was among the first to document the effects of acid rain in Canada. Viewing the issue as an important one to receive public exposure, he submitted an article on acid rain to a popular magazine. The article was rejected. The editors were of the opinion that if the lakes were being as badly damaged as Dr. Harvey claimed then someone would have noticed. With time and persistent effort, however, attitudes have changed. Major newspapers have published air pollution indices on their front pages and such indices have become part of radio and television weather broadcasts in some areas. Reports on the acidity of local precipitation have been issued by Environment Canada. Along with this considerable public education, lobby groups have arisen and are furthering the cause. Now, high-level, retired politicians lead acid rain negotiation teams, and governments are committing funds to clean up problems at their source. In the case of land-degradation issues, public perception is nowhere near this point. We have passed square one but we have not ventured far beyond it.

THE SENATE HEARINGS

At the outset of the enquiry on soil conservation and degradation by the Standing Senate Committee on Agriculture, Fisheries and Forestry, the Committee did not believe that there was a lot of solid information available to the general public. Travelling across the country and hearing presentation after presentation, the Committee realized that their initial assumption had been correct. The witnesses that came before the committee were mainly farmers, soil scientists, and a few members of the general public. They were self-interested, not

Prairie Farm Rehabilitation Administration

Wind erosion near Elbow, Saskatchewan

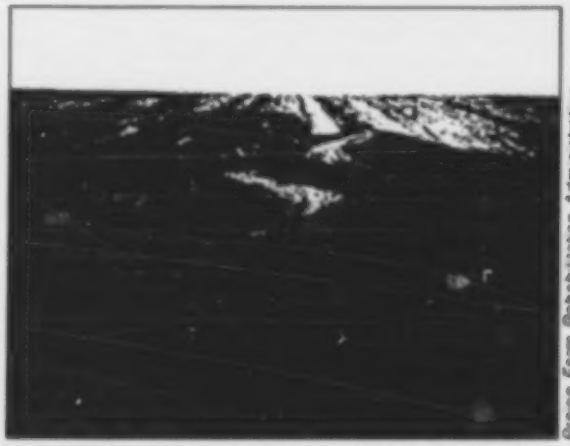
selfish. It was their land, their money, their life's work that was being hurt, and they wanted something to be done about it. They had a reason to be concerned. Although these witnesses were familiar with the problems and solutions for their own areas, they could not afford to develop them or to continue research on them.

The **level of awareness** of soil problems varied across the country. It seemed to be most prominent in areas where land degradation was the worst and where people were affected financially. On the Prairies, the land-degradation issue is well known. In the Maritimes, the Committee found that although the situation was quite serious in some areas, there was **little information available** as a basis for remedial action. In Quebec and British Columbia there was relatively less interest in problems of soil degradation than in other regions. Land-use issues were of greater concern.

Overall, there seemed to be little information on, or acknowledgement of, the fact that land degradation exists across the country, and that it is **not simply a regional problem**. It became apparent to the Committee members that many of the researchers involved in doing valuable degradation-related work were unaware of what was happening in other provinces. Representatives of provincial governments that appeared before the Committee seemed, for the most part, to be unaware of activities and legislation of other provinces. The committee found that land degradation was not perceived as a national issue requiring a consistent national policy, although many witnesses did realize the need for greater public awareness through public education.

A favorite quotation from the Committee's hearings was from a farmer in the Saint John River Valley, New Brunswick. He commented, "In the summer, after heavy rainfall, we have tourists asking why the river is chocolate coloured. We reply that it is our soils that are being washed down the river. These tourists do not realize that they are seeing their next 30 or 40 years' food supply passing in front of them." This is a concise statement, rather poetically put, of the problem that exists in the entire country and the public perception of it. It is not always soils running in rivers; it may be soils blowing across the land or it may be salt rising to the surface, but it is the same problem. **The general public simply does not have a good understanding of land degradation**. That New Brunswick farmer is right — unless the public realizes what the problems are, what the consequences will be, and what must be done to prevent these problems, we will face an even more serious problem than presently exists.

With this in mind, the Committee concluded that its greatest contribution to the problem of land degradation would be to heighten public awareness. The report, *Soil at Risk* (1984), was written with the aim of increasing awareness in the general population, both urban and rural. It was meant to present to the totally uninitiated, and to those with their own regional problems, **a national picture** of a serious **national problem**. The reaction to the report was both interesting and gratifying. In certain areas, the existence of soil degradation as an environmental issue was taken seriously. The release of the report was treated as a solid news story, often with local problems heightened, but still with a strong emphasis on the national problem and the regional variations. A major article in *Maclean's* magazine (July 30, 1984) highlighted some of the case studies that appeared in the report. Following direct meetings of Committee members with editorial boards, editorials were published in newspapers as widespread as the *Vancouver Sun* and the *Charlottetown Guardian*. Senators gave interviews to dozens of local radio and television stations. It was perhaps the first time that this particular environmental issue "made the news", other than for an immediate local or regional natural disaster.



Prairie Farm Rehabilitation Administration

Soil erosion from spring snow melt near Canora, Saskatchewan

THE PUBLIC RESPONSE

Response from the public has been greater than expected. Thirty-five thousand copies of the report were printed, most of which have been distributed. While many of the copies went to agricultural organizations for further distribution, **the Committee was committed to reach a wider audience**, insisting that copies go to such places as school boards and regional municipality offices. Copies were also sent to colleges and universities. Demands for additional copies have been so great that two reprints have been necessary, a considerable portion of the demand coming from educational institutions. Follow-up correspondence with some of the secondary schools, to see how the report had been received and how it had been used, revealed a positive response overall. It had been used as a text together with other materials on various environmental issues. Teachers from across the country indicated that their students and they, themselves, had not had any previous conception of how serious and widespread land problems are. The report was praised for being simple and straightforward in its presentation, and for providing an excellent introduction to the problem of land degradation. The case studies were often mentioned as having been very useful in getting the message across to the totally uninitiated. Indeed, most contacts expressed a need for more easily understood materials to be made available to the general public. There is obviously an untapped concern among Canadians on the land-degradation issue, a sympathy that must be nurtured.

An informal gauge of the level of public interest may be the number of speaking engagements offered to Committee

members in the past year. Since the release of the report, Committee members have been asked to speak at meetings and conferences in all parts of the country. These requests have come from various groups including the Girl Guides of Canada, environmental groups, Women's Institutes, and Women in Support of Agriculture. The former Chairman of the Standing Senate Committee on Agriculture, Fisheries and Forestry, Senator Sparrow, has spoken at more than 40 sessions since July 1984 and he is not the only member of the Committee who has taken the opportunity to make presentations to public gatherings. The Senators who undertook speaking engagements were pleased with the very positive responses that they received. In general, as they had believed in early 1984, they perceived that there was an interest in knowing about local problems, but that there was still little understanding of the land-degradation problems that existed elsewhere. Thus, their presentations were based largely on the **national land-degradation issue**. People seemed to ask questions concerning their own areas first and then gradually moved to questions regarding the rest of the country. There is a latent interest in learning about what is going on elsewhere. It is disappointing, however, that most of the speaking engagements have been to agriculturally-oriented groups. The invitations have come from farm organizations rather than from Chambers of Commerce or rural municipalities, even in areas and municipalities with serious soil problems. A few sessions have been with educational institutions, but only one in approximately 75 speaking engagements has been to a Chamber of Commerce.

It does appear that soil conservation is making progress as an issue in the public consciousness. The *Globe and Mail*, with its recent series on soil and water conservation (August 1985), has taken on the editorial challenge to provide greater awareness and action following in the wake of the report. CKCU in Edmonton is preparing a five-part series on soil conservation, and the CBC's *Nature of Things* is considering a program on soil degradation in Canada and its effects. In addition, some farm input suppliers are beginning to recognize the attractiveness of selling their products on the basis of conservation. For instance, the farm chemical company Hoechst is marketing the herbicide, Hoe-grass, on television and in newspapers as a solution to farmers who overwork their soil. The audience of these items is not solely the farmer, indeed few of whom read the *Globe and Mail* on a regular basis. Others, too, are working to increase public awareness. The Prairie Farm Rehabilitation Administration (PFRA), for example, is presently working on an educational strategy in conjunction with the education establishment in Saskatchewan.

CONCLUSIONS

Overall, in the last two years there has been an improvement in the understanding of the land-degradation issue by the Canadian public. **There is a need for a greater effort by all interested parties to bring public opinion to the point of widespread support for soil-degradation research**. Initially, this paper drew attention to the public's attitude about the environment. The *Goldfarb Report*, an annual survey of public opinion in Canada, conducts polls on both the environment and acid rain. The results show that between 1980 and 1985, public concern over these issues has steadily increased. One might venture that when the Goldfarb organization starts polling on soil conservation, we might be approaching a level of public awareness necessary to support the costly, major thrust needed to accomplish the goals we all wish to achieve. Perhaps then, the current federal Ministers of Agriculture and Environment will find the support around the cabinet table for what Mr. Wise, the Minister of Agriculture, has declared to be his second most important priority after easing the farm finance situation.

Sally Rutherford, former Director of Research, Standing Senate Committee on Agriculture, Fisheries and Forestry.

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Response from the audience:

Jean Thie: Public awareness plays a crucial role in dealing with the land-degradation problem and the Senate Committee's report itself was a major step toward this end. How can a technically-oriented group contribute to increasing the awareness of the public? What kind of audience or target group should be addressed to get initiatives going that may help to solve this problem?

Sally Rutherford: Although it sounds simplistic, the most productive thing to do is to make yourselves, and your information, available to the public. Senator Sparrow, for instance, although no expert on the subject, has the fervour to incite people to be interested. Most useful would be some sort of educational exercise of the type that PFRA is involved with in Saskatchewan. Teachers have insisted that there is a lack of good, understandable information. There is a lot of fairly technical information, but there is not very much that can be used in schools. The Senate report

has been criticized for being too simplistic, but when dealing with people who know very little, one has to start somewhere — sometimes giving them too much does not help. It has been suggested that perhaps large scale maps showing where the problems are should be made available. For example, a map showing the CN Tower and the radius of Class 1 farmland surrounding Toronto would be a simple illustration of the severity of the problem. However, such teaching aids do not appear to be available. As education is a provincial matter, perhaps you might lobby through provincial governments or provincial contacts, and try to make more information available to schools.

Alistair Crerar: When members of the environmental movement look at the soil-degradation problem, and begin studying it, they realize that much of it is brought on by farming practices themselves. Then they withdraw, saying that many of these problems are brought on by choice. What is your response?

Sally Rutherford: The whole question of supporting agriculture in general is not a simple question because farmland is privately owned. However, increasing public support puts pressure on the farmers to react. It became evident during the hearings that in areas where there was a lot of peer pressure, farmers were actively practising soil conservation techniques. It has an impact. If there is enough hue and cry and farmers are able to afford it, perhaps things will change, but the hurdle to be overcome is explaining to environmentalists that they must persist, that there is no reason to stop. One could liken the situation to that surrounding the acid rain issue. The fact that many large corporations consciously cause emissions resulting in acid precipitation has not discouraged concerned individuals from continuing to work for change. I am sure that farmers are a lot easier to deal with than multi-national corporations.

Jean Thie: I wonder whether the foresters present can contribute something here. In my perception, the forest-regeneration issue has been raised in a relatively short period of time and there are significant federal and provincial actions in response to that initiative. Approximately three or four years ago, the forestry community orchestrated a movement of the professional, industry, and labour sectors to influence decision making. This resulted in the establishment of the Ministry of State for Forestry which, through the *Economic Regional Development Agreements* (ERDA), could support forest regeneration which is a form of land management. I wonder if it is applicable to the issue of land degradation. It may be more difficult to deal with the public than with the large corporations in the forestry sector, but perhaps we can use our professional links to provide a type of stimulus. I raise this as a public awareness issue leading to government action.

Gordon Weetman: Yes, I believe you are right. There has been much concern over land degradation, but there has been little concern over forest degradation. Forest degradation is much more insidious and quiet, whereas agricultural degradation is often much more obvious.

Barry Smit: Is there a certain type of information that is necessary to key public response? For instance, we seem to have a lot of information on where the agricultural land is, a little bit on what the process of degradation is, perhaps a little bit on where it is, but there is not a lot on what the implications of it are. How is it going to effect individuals or society in general? Regarding acid rain, was it the fact that there was information on what it might mean for society or for individuals? Is there a difference in the type of information that is needed in order to get an item into the public awareness and then onto the political agenda?

Sally Rutherford: As far as air pollution goes, people do not like to breathe poisoned air. Acid rain kills lakes and fish, and that affects people morally because they do not like dead things. As for the soil, people generally see it as inanimate. It is more difficult to see the damage that soil degradation is doing. The loss of agricultural land is also difficult for the average person to see. When they go driving they see lots of land and it does not occur to them that it may be divided up for other uses, as Bruce MacLean showed us in Manitoba. Unfortunately, perhaps self-interest is a key to public concern. The little trigger must be found that will make land and forest degradation of self-interest to the general public. Perhaps the trigger is related to their future, or to their children's future, or to their food supply, or to their ability to use the lake, etc. It is unfortunate, but it was largely self-interest that prompted people to appear before the Senate Committee at the hearings. Again, I want to stress that this does not mean that these people are selfish. This is simply how they were able to recognize the problem and why they wanted to do something about it.

LAND DATA REQUIREMENTS FOR NATIONAL POLICY AND PROGRAM FORMULATION

Edward W. Manning

The land resource is a vital element in the economy, society, and environment of Canada. Forty-five percent of the gross national product and 25% of all jobs can be directly traced to the land resource, that is, the use of the land for productive enterprise. This paper explores the major land-related elements of federal responsibilities, and documents the strategic requirements for land-base information in order to support these responsibilities. In particular, this paper focusses on the need to measure changes in the use of the nation's land resource.

THE NATIONAL ROLE

The federal government under the *Canadian Constitution* has a wide range of mandated activities relating to the land resource, to individual economic sectors, and to environmental maintenance. The first part of this paper documents specific areas of federal responsibility which have requirements for land-resource information.

Management of Federal Lands

The federal government is the nation's largest landowner. It has direct responsibilities for most of the land north of 60°, for major federal holdings such as national parks and defence establishments, and for significant areas of strategic lands in the settled part of Canada such as the St. Lawrence Seaway holdings, federal office buildings, ports, experimental stations, etc. To better manage its landholdings "so as to combine efficient provision of federal government services with the achievement of broader, social, economic, and environmental objectives" (Treasury Board Canada, 1982), the **Treasury Board Advisory Committee on Federal Land Management** reviews all land transactions and major changes in use to ensure that these objectives are fulfilled. Information on the present and/or destination use of each holding is required to permit better decisions relative to surrounding land uses. The current use and trends in regional land use for these areas aid in the decision process. One of the objectives of the *Federal Policy on Land Use* (1980) is to ensure that local, regional, and provincial concerns are met.

The Impact of Federal Programs

In 1980, upon approval of the *Federal Policy on Land Use* by Cabinet, the federal government accepted direct responsibility for the impact of its own programs on the land resource. To fulfill this responsibility, the **Interdepartmental Committee on Land** was established, with one of its objectives being to review the impact of federal policies and programs on the use of the nation's land resource. For the Committee to conduct this type of review, it requires information on land-use trends, on major national and regional land-use problems and issues, and on the specific role of federal policies and programs related to these. Such information is a major element in the Committee's ability to understand current and potential problems and to influence federal programs in support of positive land-use trends or to mitigate land problems.

National Economic Management

The federal government has an overall national mandate to maintain the **economic well-being and sustainability** of Canada. Information on the availability of land, current uses, and inter-sectoral problems can play an important role in guiding the planning process. For example, knowledge of land-resource opportunities and constraints is central to the direction of federal investments in renewable resource development. Originally, programs under the *Agricultural and Rural Development Act* (ARDA) of 1961 were designed to provide this basic information to direct federal regional development investments. This need still exists, although the operating agencies have changed and the direct ability to influence strategies often is not realized. In particular, sectoral development policies involving agriculture, forestry, transport, tourism, etc., rely on the availability of adequate land of suitable capability for their achievement.

Environmental Maintenance

Under the *Department of the Environment Act* (1978), the federal government has the national responsibility for the maintenance of soil quality and for renewable resource management. Hence, baseline information on environmental quality, on the resource capabilities of specific lands, and on their current use is required. This permits government to identify, on a national scale, overall levels of environmental maintenance, and to target specific areas, particularly those with high capability or scarcity.

Advice and Planning Support

While the federal government can only act with respect to its own lands and programs, its role is also to supply **national level information** to those able to take action. Land and regional development planning normally is done at the provincial government or municipality level. To provide advice, new information and/or new techniques must be brought to the table. Broad, objective information at the national level provides a milieu within which local or regional planners can make decisions. Regional comparisons aid local planners in understanding whether their areas have particular problems from a national or regional perspective, and can help to identify areas which need specific attention. A related federal role is to provide planning assistance to develop techniques which deal with particular planning problems, usually related to prime resource lands. Knowledge of current land uses and land trends is critical to the development of suitable methodologies.

Public Information

Under the *Environment Act*, the public must be informed of major environmental issues and trends. The federal government's role is to support the long-term sustainability of human occupance in Canada, to foster an environmental ethic, and to promote stewardship of our natural resources. In support of this role it has the specific mandate to provide nationwide environmental information, to highlight major environmental trends, and to identify specific problem areas. To do this, comprehensive knowledge of the current status of the land base, as well as its use and trends is required.

From the above functions, it is clear that the federal government has a broad role in influencing wise land-use and/or environmental management across Canada. Definite information requirements are evident, both at a broad national level in support of national perspectives and overviews, and at a level which permits the government to target particular problems and anomalies for further attention, often jointly with local authorities. The federal government is also responsible for identifying key local problems which, due to their social, economic, or environmental implications, can have national-level repercussions. An example of this is the local phenomenon of fruitland loss in the Niagara region which, because it involves over one-half of Canada's fruit and grape production, is of clear national significance both in terms of self-sufficiency and balance of payments.

KNOWLEDGE REQUIREMENTS TO SUPPORT THE FEDERAL MANDATE

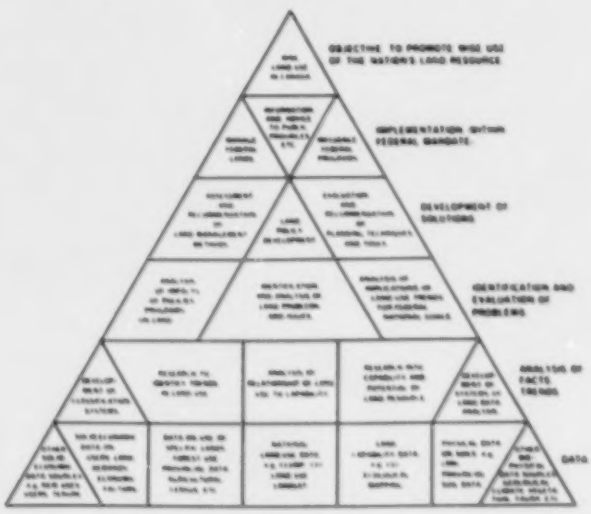
If the federal government is to effectively fulfill its mandate, it has very specific knowledge requirements relating to the land-resource base. To organize the specific elements of this requirement, a conceptual pyramid (*see* Figure 1) has been created. This establishes the federal mandate at the top and shows the various levels and steps required in order to achieve it. Five levels of the pyramid are required to support this mandate: implementation, development of solutions, evaluation of problems, analyses of trends, and the development of factual information. The entire logical structure is built upon a base of data and information which is critical to the fulfillment of any of the other functions. Time series or trend data is central to most of the analytical and problem-identification functions. Included in the requirements are data on the changing use, tenure, management, and quality of land.

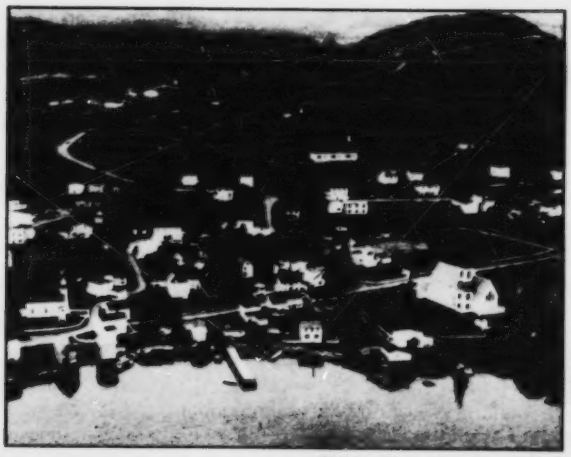
There are a number of identifiable functions which rely directly on land-use change information. Sound baseline information is required as well as a method of extrapolating this information through time series to measure changes. This paper identifies six specific functions in support of the federal mandate and examines the specific information characteristics necessary to allow these functions to occur effectively.

1. Identification of National Trends and the Evaluation of their Causes and Consequences

To carry out the mandated responsibilities (particularly to influence policy and to inform the public), it is necessary to identify major national trends. In addition, where these trends appear to be creating problems, specific causes must be identified and the consequences evaluated with respect to individuals, regions, or the nation. Here, data are required which remain consistent over time, which are nationwide and therefore comparable from region to region, and yet are sufficiently detailed that the specific problems of individual locations can be identified. The type of national trend which is of major social, economic, or environmental consequence would include significant shifts in land use, particularly those which cause land to be put to uses which are not sustainable in the long-term or which cause major economic or social dislocations. Such data must also be timely; they must identify major trends as they are occurring. Therefore, the collection cycle must be as short as possible. Also, the categories of information must be meaningful. They must identify trends which are of direct social or economic consequence, not ones reflecting only internal shifts

Figure 1
Building Towards Wise Land Use and Management in Canada – The Federal Role





D.A. Wilson

Trinity Bay, Newfoundland

within industries. Current priority data requirements include identifying major land-use trends on prime agricultural lands and prime wildlife habitat areas (including wetlands), as well as obtaining time-series information on both the state of management and levels of degradation of these lands.

2. Modelling the Outcome of Trends and Policies

For effective response or preventative action, crises must be predicted before they occur. This requires the ability to look to the future through any number of modelling, extrapolation, or scenario-building capabilities. However, the utility of the results of such processes is heavily data-dependent. If it is not known what is there now, it becomes even more difficult to predict what will be there in the future. Time-series information showing baseline and change information for land capability, use, management, and ownership is critical to any mathematical ability to deal with future scenarios. The scale of data collection for such modelling purposes at the national level does not involve detail. Instead, it requires generalized data but for spatially consistent units. The current land evaluation modelling exercise at the University of Guelph (Smit, 1981) is one example of a scenario-building application which is heavily dependent on data regarding land capability, productivity response, and current land-use trends.

3. Identification of Strategic Regions of Concern

The identification of target areas, anomalies, and areas of concern is a vital element in supporting the national role. Data requirements again include consistent data which focus on trends across the nation, relative to the known characteristics of the land base. Answering questions such as, "where is the greatest intensification of land use occurring in Canada and on what land capability?" lead to the ability to project sustainability of such land uses. Federal programs could be targeted to areas that have been identified at the national level as posing potential problems. Nationally consistent information is vital to being able to understand the overall national picture, as well as the types of pressures on prime producing areas. Due to the national dependence on raw materials, particularly renewable resources, such information should include measures that are specific to the agricultural and forest sectors.

4. Supporting the Need for Action or Policy

The nature of the decision-making process means that action seldom occurs until the evidence is so overwhelming that action becomes essential. While there may be a general public understanding that land degradation, the urbanization of prime lands, or the loss of wetlands is of concern, the stimulus to act seldom occurs until this has been quantified to the extent where no reasonable person can possibly question the existence or severity of the phenomenon. Thus, to be able to document at appropriate levels, the severity of wetland loss and the precise nature, extent, and location of urbanization on prime agricultural land is central to the ability of all governments to act. However, such action is heavily dependent upon information being accessible in an easily understandable and useable form for the general public and decision makers. The existence of an objective and scientifically-sound national base of land-use change analysis is a vital element in the ability of Environment Canada, or any other agency, to carry out successful programs to deal with identified land problems.

5. Reporting to Canadians

The ability to report to Canadians is dependent upon information which is easily understood, comprehensive, and scientifically sound. Political action depends upon the public understanding that there is indeed a problem and supporting the decision makers when they choose to act. Thus, the ability to report directly to Canadians on trends, positive or negative, in the use of their land resources is a vital element in this objective.

6. Evaluation of Federal Program Impact

For the federal government to remain accountable for its actions, it must evaluate the long-term implications of its programs relative to the *Federal Policy on Land Use*. This includes the impact of both specific programs and mitigative actions taken to assist in the wise management of Canada's land resource. To do this, baseline information on land-use changes and trends is a central factor. Analysis of trend data can evaluate the effectiveness of federal programs in supporting the *Federal Policy on Land Use*. The national data requirements for this are similar to those required for the evaluation of causes and consequences. Already, a major study of the fruitland industry in British Columbia's Okanagan Valley (Kerr, *et al.*, 1985) has focussed specifically on the relationship of federal funding and trends in land-use change.

USING WHAT WE CAN BEG, BORROW, OR STEAL

There are two strategies for obtaining land information for national level policy and program support. These are: using what is already in existence, and attempting to develop derived information; and developing programs to obtain it ourselves. Both strategies are currently being pursued. In this final part of the paper, the current adequacy of information is explored along with some of the advantages and disadvantages of different options.

Canada is indeed fortunate that the **Canada Land Inventory** (CLI) was undertaken in a time of relative prosperity and interest in regional economic development for the ecumene of Canada. This, in itself, provides an excellent data base with respect to the physical nature of the land resource. Late 1960s land-use information is also available from the CLI. Similarly, **soil surveys**, **forest inventory**, the **population census**, and **agricultural census** provide a wide range of usable variables that allow us to broadly evaluate land-use trends. While there has been a number of problems with data consistency in terms of definition and boundaries of such available data sources, it has been possible to make some accommodations with these data sets to allow development of overview information at a broad regional level. The **Canada Land Data System** (CLDS) has the capability to overlay information on any boundaries, and thus, can indicate regional relationships between census information and land capability characteristics. Within the Lands Directorate of Environment Canada, a program has been developed called the **Rural Land Analysis Program** (RLAP) which attempts to integrate a wide range of census, CLI, industry, climatic, and other data on an administrative unit basis. Thus, it is possible to obtain an overview of land-use trends involving agricultural land use or major crops, industrial indicators of employment levels or total product (e.g., volume or value of forestry production), and relate these to particular spatial areas. It is also possible, especially for agriculture, to identify losses or gains of land for a specific activity (e.g., *see* Figure 2). However, other than at a broad regional level, neither the capability nor the destination use of land are evident. Furthermore, due to the nature of collection and confidentiality of the data sources, it is usually necessary to operate at a county or township level, thereby diminishing the capability to understand the precise processes at work and the specific relationships between land-use trends, land capability, and land management.

MAKING OUR OWN

The following example serves to show the necessity of obtaining further information through empirical collection of land-use information. In the Gaspé Region of Quebec, a study (Lamoureux, 1986) has recently been completed to analyze the disappearance of vast quantities of agricultural land from census farms between 1961 and 1981. While a detailed analysis of census, industry, and questionnaire sources was undertaken at the township level, this proved inadequate. An analysis of field-level land-use changes between 1961 and 1981 was undertaken using the **Canada Land Use Monitoring Program** (CLUMP) approach which employs direct air photo interpretation and overlay procedures. This revealed the destination of "lost" agricultural land and showed that 85% remained in an unused state, neither reforested nor used for any other evident economic activity. The agricultural and forestry capability of this land was also documented, showing that the land had reasonable potential for forest production (mostly classes 3 and 4) but poor agricultural capability. This information has been provided to those negotiating the current regional development agreement involving the Gaspé Region. If such analyses were available throughout Canada, the information would be invaluable to the longer-term targeting of regional development assistance to forestry and agriculture.

E.W. Manning

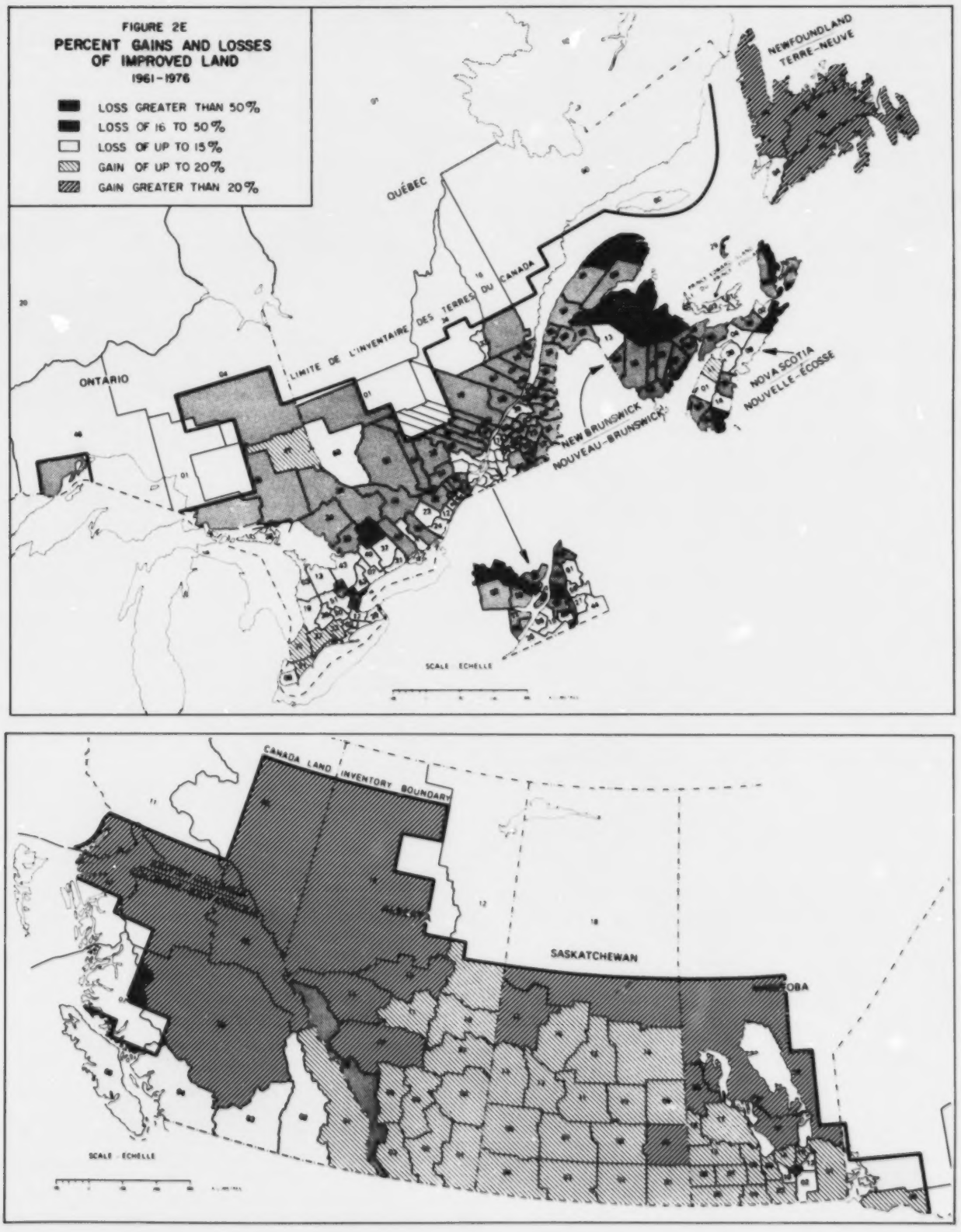
Rural residence near Carillon, Quebec

The same lesson can be learned from a recent study of fruitlands in the Okanagan Valley of British Columbia (Kerr, *et al.*, 1985) undertaken jointly through the **Federal Impact Analysis Program** and the **Canada Land Use Monitoring Program**. Census, industry, and other sources were certainly useful in obtaining an overall picture and in understanding long-term trends involving the fruit industry as a whole. However, to identify areas where critical problems exist and take any mitigative action, a more detailed methodology seemed essential. Both the Okanagan study and the Urban Centred Region (UCR) component of CLUMP have added a critical dimension to our ability to understand what is really happening to Canada's land. The latter has allowed us to identify those urban centres where high capability agricultural land is being urbanized, and to relate rates of land-use change per capita from centre to centre. As well, land-use change data have been central to pressures put on several provincial governments to undertake zoning legislation on prime agricultural lands (e.g., the Regional Municipality of Niagara, the British Columbia Agricultural Land Reserves, and Bill 90, the Quebec Law to Preserve Agricultural Land). The ability to show the quality of land being urbanized and the rates and destination uses is a dimension unavailable from any other data source.

Major questions which arise regarding monitoring include concerns for **level of detail**, **timing**, and **variables to collect**. The federal requirement for data usually involves identifying target regions or assembling broad regional or national data. With the exception of particular projects or for specific land management purposes, more detailed data often are not required or mandated. Other users, however, may have much more detailed requirements.

For long-term projects one has the luxury of a longer cycle or response time, but if policy or program responses are required often information is required in very short order. Typical turnaround times for policy requests received in Environment Canada range from one day to one week. Thus, information availability is vital to putting constructive input into such processes as regional development strategies, cabinet documents on sectoral policies, and plans for major developments involving land. There is a need to maintain, particularly for priority areas, an ongoing monitoring capability. While it is not always possible to anticipate the questions which will arise, many can be

Figure 2
Percent Change in Farmland Area (1961–1976)



foreseen based on economic and demographic trends and experience. The answers required are often quite general. Flexibility and quick turn-around are essential. However complex and specific, the data must be capable of synthesis into fairly general yet consistent and easily understood measures that explain change and its implications. For example, the meaningful statistic for a policy dealing with urban growth is not one that deals with changes from a particular industrial use to quarrying, but rather one which deals with general urban use, as opposed to rural use, as opposed to recreational use.

The current priorities of Environment Canada with respect to land are **land degradation**, **prime resource lands** such as prime agricultural lands (including fruitlands), and **prime wetland** areas. Response involves the collection of information on land-use change and on changes in the quality and levels of land management. Yet, resources preclude collecting everything everywhere. The Canada Land Use Monitoring Program has established priorities within its overall objectives. Clearly, a comprehensive inventory of land use at a detailed level in Canada is not practical given the current level of economic constraint, the federal mandate, and the size and diversity of Canada. Therefore, the strategy focusses on prime lands, those where decisions can affect the socio-economic and environmental fabric of Canada. However, the current level of information is not adequate. We are able to anticipate some danger points, but we may well be missing serious problems because of the lack of key information on land. No land quality baseline exists which would allow valuable input into the land-degradation question on the Prairies. It is not even known what the major land-use trends are in this area because it has only recently been targeted as a priority area for land-use change monitoring. Thus, general census information must be relied on for particular crop trends, intensification, and fertilizer use, rather than specific measures of land use. Similarly, in the key arguments over sustainability of renewable resource development in the marginal areas of Canada, only a few specific studies exist. The ability to evaluate where funds should be targeted to best strengthen the forest industry or to rescue productive agriculture, for example, is largely lacking.

CONCLUSIONS

The objective of this paper has been to identify the key requirements for information, relating to the land use of Canada, for input into the policy-making process. Too often, decisions are made without adequate information on the long-range repercussions of misuse and overuse of valuable resource lands. The conclusion is that there is a major economic price to be paid if land-use change information is not incorporated in a meaningful way into the decision-making process. This requires the existence of adequate data, as well as its transformation into the information required by, and acceptable to, decision makers.

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Response from the audience:

Gordon Weetman: One of your overheads illustrated trends in the relationship between agricultural land capability and improved cropland. As a question of mandate, would the federal government be allowed to look at forest land capability and improved silviculture?

Ted Manning: Although there is a national mandate through the Forest Research Group in Petawawa who are presently developing a standardized forest data base, the collection of forest information is provincial. This has caused some difficulty in pulling consistent information together at a national level. Presently, if a politician asks about the amount of forest land or forest supply problems, we cannot respond very well. However, progress is being made towards improving the forestry data base.

There is a national mandate to gather national level information. Generally, this is done jointly with the provinces simply because their data requirements have tended to be more detailed. Therefore, as long as there is some degree of consistency, the extraction of consistent national level data should be easier. In the case of agriculture, the census does it at a generally agreed level for everyone. From a mandate point of view, I can see no barrier to dealing with all sectors in terms of land-use data.

Neil Seely: Have you looked at the model of the Canadian Forest Inventory Committee (CFIC) as a potential model for gathering information for land use generally across Canada? The information gathered by the Canadian Forestry Service (CFS) is less than perfect but it represents a giant leap forward. Would that model be useful for your work?

Ted Manning: We have been talking directly with the Petawawa National Forestry Institute to try to access their information. There are still some difficulties, but I think it is certainly the best way to get forest sector information, unless more holistic work is completed looking at all sectors simultaneously via a comprehensive land-use monitoring program. However, this would probably be more area-specific than nationwide.

— WORKSHOPS —

LAND-USE MONITORING AND DEGRADATION RESEARCH:

ISSUES AND ROLE

A. Land-Degradation Monitoring: Why? Where? For Whom?

B. The Role and Status of Land-Use Change Monitoring Regionally and Nationally in Canada.

C. User Requirements for a Land-Use Monitoring Program.

D. The Contribution and Impact of Monitoring on Policy Formulation, Evaluation, and Program Planning.

E. Priority Areas in Canada for a Land-Use Monitoring Response.

F. Prime Resource Sectors or Issues which Warrant a Monitoring Response.

A. LAND-DEGRADATION MONITORING: WHY? WHERE? FOR WHOM?

Chair: Martin Tabi
Rapporteur: Gerry Luciuk

Dell Coleman
John Girt
Fernand Martin
Réal Michaud
Roberge Michaud
Sally Rutherford
Wendy Simpson-Lewis
Dennis Walsh
David Wilson

QUESTIONS ADDRESSED

- What is the status of land-degradation monitoring in Canada?
- What aspects of land degradation are most significant to monitor? Why?
- What are the critical tasks that need to be accomplished to establish an effective land-degradation monitoring program?
- Where is a monitoring response to land degradation most required?

The participants of this workshop agreed that there is a need to monitor land degradation in Canada. In addition to "why", "where", and "for whom" land degradation should be monitored, group members also recognized the need to discuss "what" should be monitored.

WORKSHOP DISCUSSION

Land-degradation monitoring is required for many reasons. The preservation of soil resources is of national interest. It is the responsibility of the present generation to preserve the land which forms the basis for our food production. Reference points are needed for researchers to be able to establish trends and determine the effects of various human practices on the environment (e.g., acid rain, cultivation practices, etc.).

Trends established from monitoring land degradation will alert farmers to the need for them to adopt conservation practices that make more sensitive use of the land. Accordingly, there are both research and technology application implications.

Decision makers at both the field level and the political level influence land degradation. Policy making is involved in responding to specific areas where degradation becomes an issue. For example, in the agricultural sector there have been sporadic political interventions since the 1930s.

It is not feasible to wait for the ideal data base. A considerable amount is known about land degradation in the agricultural sector, but now there is a need to synthesize and evaluate existing data which may have potential for monitoring land degradation (e.g., *Soil Survey of Canada*). The forestry sector is examining the evolution of the problem using established data sets for identification and quantification, and to determine trends on the nature and scope of forest degradation.

When discussing "where" land-degradation monitoring should be undertaken, the group recognized that there were federal, provincial, municipal, and time-frame considerations. Those areas where degradation is most severe may not figure prominently in decisions on which sectors receive the priority, jobs, and money. Monitoring one type of degradation may cost more than another in one location as opposed to another. Furthermore, decisions made in eastern Canada will differ from those made in western Canada. What is beneficial for one province in the east, for example, may not be beneficial for its neighbouring province or for the Prairies.

E.W. Manning

Unstable slopes near Pincher Creek, Alberta

Appropriate time frames for land-degradation monitoring vary depending on the perceived priority. The time frame for farmers and politicians is the present and immediate future, while a researcher's time-frame is more long-term. Therefore, the decision of "where" to monitor land degradation will vary depending on the perceived use of the information obtained.

In allocating resources to land-degradation monitoring, as opposed to solution-finding or assistance, it was stressed that physical-based systems do not necessarily translate well into economic terms. Where problems are complex, sophisticated monitoring systems are required. Presently, too many inadequate systems are employed to evaluate complex problems.

It was generally agreed that land-degradation monitoring should be undertaken by provincial and/or federal governments. Land degradation must be monitored for future generations, and for farmers, foresters, and politicians at all levels.

Generally, it was recognized that from an issue viewpoint, obvious candidates for land-degradation monitoring include the forests in British Columbia, salinity in the prairie provinces, and soil erosion in Ontario. Nationally, problem areas need to be defined and addressed, but presently, a collective effort to do this is lacking. A forum such as the Intergovernmental Committee on Urban and Regional Research (ICURR) was suggested for sharing research information and data.

SUMMARY

There is a need to undertake land-degradation monitoring to establish trends. Preferably, this should be accomplished by provincial and/or federal governments. It was concluded that a forum such as ICURR be used to share research information and data.

Existing data pools must be evaluated and used rather than trying to establish the ideal data base. In addition, it was recognized that research, technological, and political considerations should be reflected in land-degradation monitoring. Such considerations will vary between sectors, levels of government, and regions.

B. THE ROLE AND STATUS OF LAND-USE CHANGE MONITORING REGIONALLY AND NATIONALLY IN CANADA

Chair: Michael Dillon
Rapporteur: Lorne Russwurm

David Gierman
Brian Haddon
Ralph Krueger
Bruce MacLean
Lawrence Peters
Mark Poirier
Greg Roberts

QUESTIONS ADDRESSED

- How does land-use change monitoring contribute to addressing major land-use issues? Provide examples.
- How do various individuals agencies use land-use change monitoring information?
- How effective are present land-use change monitoring efforts in achieving the goal of wise land resource management in Canada?
- What is the status of land-use change research in the various regions of Canada?

WORKSHOP DISCUSSION

Initially, considerable discussion revolved around the meaning of monitoring. It was concluded that monitoring involves measuring change of an environmental variable over time. To accomplish this, initial baseline data is required. Two roles for land-use monitoring were identified: a) to gather data from which change can be detected; and b) to gather data for "watchdog" purposes, for example, change in air pollution indices. In addition, three types of focus in gathering monitoring data were identified: a) to **provide** comparable data collected systematically over specific time intervals; b) to **interpret** data from the perspective of change-analysis; and c) to **analyze** the data to assess specific objectives, for example, loss of prime agricultural land.

Two views arose from the discussion. First, monitoring is frequently undertaken in response to a crisis issue identified by the public or government with a consequent need for action (e.g., soil degradation). Second, a more comprehensive approach is taken where environmental variables are identified on a priority scale and monitored on an ongoing basis. Implicit in this second approach is an attempt to look into the future to anticipate what variables should be monitored.

The group noted two concerns. Knowledge is limited regarding the research activities and capabilities of monitoring agencies. For example, it was necessary to provide an overview of the Canada Land Use Monitoring Program (CLUMP) during the introduction to the workshop. Moreover, the capability of potential users to quickly understand the significance of monitoring data was questioned. Complex monitoring data tends to be ignored. National level monitoring demands that simple measures be readily comprehended by non-specialists. The Standing Senate Committee on Agriculture, Fisheries and Forestry report, *Soil at Risk* is an example where good, simple information was provided on one specific issue of national importance.

Various examples of monitoring efforts were discussed including the use of forest inventories for establishing allowable cuts, monitoring the conversion of agricultural land to other uses, and monitoring the degradation of wetlands. The group concluded that too much monitoring work is aimed sporadically at a particular issue and subsequently dropped after a limited time period. Greater attention should be given to providing data to users in a form they can easily use. Furthermore, cooperation between the different levels of government needs to be strengthened to achieve a coordinated land-monitoring system.

Several examples of Canadian research were discussed, notably the use of remote sensing for change detection, the land information network in New Brunswick, forest monitoring in British Columbia, and the individual effort of Ralph Krueger (University of Waterloo) on fruitlands. To achieve consistent monitoring over time, it was agreed that land-use monitoring needs to be linked to ongoing, funded sources which provide essential data. Assessment rolls and the Census of Canada were two sources which were especially emphasized.

The group expressed optimism regarding the development of improved and more consistent monitoring of land use and other environmental variables. A considerable number of experienced, well-trained researchers are involved in monitoring today, compared to 20 years ago. However, concern was expressed over the ability of technological advances to provide answers for large numbers of people rather than for small numbers of specialists.

SUMMARY

Environmental variables should be identified on a priority scale and data should be provided and interpreted on an ongoing basis. Then it may be possible to anticipate which variables should be monitored. National-level monitoring information needs to be made simple and understandable to non-specialists. Furthermore, users must be provided with data in an easily-usable form. Good monitoring research is being conducted throughout Canada. However, to achieve consistent monitoring over time, existing data sources that have ongoing funding should be considered for land-use monitoring purposes.

C. USER REQUIREMENTS FOR A LAND-USE MONITORING PROGRAM

Chair: Norman Drummond
Rapporteur: Michel Melançon

Robert Cournoyer
Alistair Crerar
Pierre Desforges
Monique Léonard
Neil Seely
Barry Smit
Floyd Wilson

QUESTIONS ADDRESSED

- Who are the users? What level of detail (scale, classification system) is required? What are appropriate formats (maps, graphs, tables) and monitoring cycles?
- Accepting the term "land use" in its broader sense, what attributes of land use should be monitored (e.g., cover, activity, tenure, quality, etc.)? Can these be assigned a priority?
- How important is data comparability, temporally and spatially, to users? At what level (regional, provincial, national) is it important to achieve comparability?
- Is land-use monitoring information being used effectively in its present form for planning, management, policy formulation, etc? Are there changes that can be made to more fully meet user requirements?

WORKSHOP DISCUSSION

Monitoring land use (land occupancy, allocation of land) must meet a wide range of needs. In fact, there are potentially as many needs as there are users. Regional planners and managers employed by municipal, provincial, federal, and private agencies are among the list of users, as well as researchers in disciplines related to natural sciences and the humanities, such as geography, urban development, agriculture, wildlife biology, forestry, etc. All of these specialists strive to gather specific data to assess land-use change and natural-resource degradation. This information broadens our knowledge about the environment and provides the necessary tools for developing policies and guidelines on the wise use of natural resources.

Land-use data take on their full significance only insofar as they are weighed against resource capabilities. Canada Land Inventory (CLI) land capability maps for agriculture, forestry, wildlife, and recreation, although they date back to the late 1960s, constitute a very valuable pool of information. The scope of this inventory could be broadened appreciably by updating the data to incorporate the latest scientific and technical knowledge. Ecological studies conducted in recent years have made it possible to assess available renewable resources and to determine their capability. It would be worthwhile, however, to reinterpret these studies to make them appropriate for regional planners.

Elements considered in studies on land-use change (land occupancy, land cover, tenure, quality of resources, etc.) must be reviewed in conjunction with socio-economic change (population, income, education, etc.). This provides a better understanding of land-use change trends and contributes to informed decision-making.

Without doubt, any land-use decision must be made on the basis of comparable data in terms of both time and space. The rapid growth of computer science, more specifically micro computers, leads one to seriously question the compatibility between systems. It is essential that environmental data be analyzed by computer systems with interface capability. Computer simulations can be completed using existing data on land use, resource capability, and socio-economic aspects. Such simulations can guide resource management and facilitate policy development. This type of modelling is relatively new in Canada.

SUMMARY

Land-use change data needs are considerable and many data banks are necessary to satisfy user needs. Data from land-use monitoring must be analyzed jointly with resource-capability data and socio-economic statistics. Furthermore, land-use change simulations must be conducted to analyze the potential impact of change on resources. Decision makers must familiarize themselves with these various types of data in order to ensure adequate environmental management.

D. THE CONTRIBUTION AND IMPACT OF MONITORING ON POLICY FORMULATION, EVALUATION, AND PROGRAM PLANNING

Chair: Craig Taylor
Rapporteur: Anne Kerr

Ken Beanlands
Alfred Birch
Michael Brklacich
Paul Brown
George Jackson
Larry Martin
Geoff McDonald
George McKibbon
John Pierce

QUESTIONS ADDRESSED

- To what extent does land-use change information contribute to policy formulation, evaluation, and program planning? Can this contribution be strengthened?
- Should land-use change monitoring be an integral part of evaluating land- and resource-use plans and policies regionally, provincially, and nationally? If so, through what mechanisms/processes?
- To be most effective, should monitoring programs be designed to meet specific needs or be designed to be global in nature to serve a variety of purposes?
- How can the results of land-use change monitoring be applied to assist decision makers?

WORKSHOP DISCUSSION

This wide-ranging workshop discussion was enhanced by a good combination of federal, provincial, regional, and university representatives. From the outset, it was recognized that monitoring should be related to a societal value-structure. Not only is there a need to know the extent of the "problem" to be monitored, there is also a need to know the value of that problem in relation to public perception and socio-economic parameters.

Three levels/types of monitoring were identified:

- **Intelligence-level monitoring** was recognized primarily as a collection of "baseline" data such as that produced by Statistics Canada. Such data did not seem to be well-translated to the policy-making level;
- **Research-level monitoring** was seen as meeting more specific objectives. It was felt, however, that most policy formulation was done on an ad hoc basis, particularly in certain provinces, mostly because monitoring data was simply not available for use; and
- **Audit monitoring** was viewed as having a valuable role in environmental impact assessment. Rather than undertaking costly and lengthy studies in an attempt to predict a project's environmental impact, monitoring the effects of a project could provide a continuous "audit". From this, policies could be formulated or re-evaluated.

In general, participants felt that monitoring systems were maturing. They recognized that it is time consuming both to get monitoring programs underway, and for people to become aware of the value of land monitoring information. Nevertheless, monitoring is beginning to be used in program evaluation and policy development. It was agreed that monitoring programs need to be extended from the data-gathering stage to the "what if" or modelling stage. To be useful in policy formulation, the results of monitoring programs must be used to predict future trends. Socio-economic data must be integrated with physical data in a successful monitoring program in order to better reflect human factors in land-use trend formation.

G. Greenberg

Monitoring for Change Workshop participants

The value of a resource must be made a recognizable issue to heighten public awareness. Sometimes "good" press aids in this respect. An example from an Australian newspaper heading relating to soil erosion read: "Darling Farms bleed black blood"! Where livelihoods are at stake because natural resources are endangered, monitoring programs tend to receive government support. For example, dwindling stocks of both the east and west coast fisheries have caused alarm, resulting in substantial monitoring efforts.

It will be difficult to give monitoring a higher public profile for several reasons. The results from monitoring programs tend to require temporal cycles longer than the tenure of most politicians. Politicians want results in a three- to four-year time span. In addition, there is no identifiable interest-group that is vocal in raising land-use issues in the public domain. Thus, there is a need to promote monitoring in order for it to become part of policy development. Monitoring must be packaged in value terms that politicians use and respond to. Furthermore, the package must be "user-oriented".

SUMMARY

Some frustration is experienced by data producers because their monitoring information is under-utilized, particularly with respect to policy formulation, project evaluation, and program planning. Monitoring needs to improve its image. Rather than simply identifying past mistakes, it should show how risks in the future can be minimized by using trend analysis and scenario modelling.

The notion that all change is negative must be challenged. Instead, the reasons for change must be emphasized. For example, in the Okanagan fruitlands there has been a loss of orchards, but there has also been a land-use adjustment from orchards to vineyards. This change does not result in a net decline to the fruit industry as a whole. The results of land-use and land-degradation monitoring must be described and presented in terms attractive to politicians, policy developers, and decision makers.

E. PRIORITY AREAS IN CANADA FOR A LAND-USE MONITORING RESPONSE

Chair: Corwin Cambray
Rapporteur: Joseph Arbour

Alan Aldred
Ted Manning
Terence McCrae
Harold Moore
Richard Mussakowski
Jean Séguin
Gordon Weetman

QUESTIONS ADDRESSED

- What are the priority areas in Canada requiring a land-use monitoring response (e.g., geographical areas, types of changes, areas of rapid change, areas undergoing resource development)?
- How should priority areas be decided upon? How can they be rated according to priority?
- What importance should be placed on obtaining information for new areas versus updating?
- In the past, rural-urban fringe studies were considered important areas for monitoring land-use change. Does the rural-urban fringe remain a high priority for monitoring programs?

WORKSHOP DISCUSSION

The wide-ranging discussion reflected the complexity of the problem due to the diversity of both land and attitude in Canada. A priority-setting model was developed by the group for use in synthesizing the large volume of land data to determine monitoring priorities.

The major areas requiring a land-use monitoring response were identified relatively easily. Priority areas suggested were: forest lands (particularly in northern areas), the Niagara region, aggregate-producing areas, and wetlands. However, no concensus was reached concerning the relative priority of one area over another. Consequently, it was concluded that a means to assess priority was required.

During a wide-ranging discussion on priority setting, a consensus was reached on the purpose of land-use monitoring. It was concluded that monitoring is necessary to forecast in order to predict potential crises. The process of priority setting was then discussed. Several major categories of information were identified as being essential for the assessment of priority. These represent the **criteria** against which monitoring decisions should be made. Three major criteria were judged appropriate: economic value; intangible value; and criticality of pressures.

The **economic value** considers the inherent value of a resource as a commodity in terms of public investment in the resource and the resource's contribution to economic growth through employment and income. Some of the economic information required to judge priority for land-use monitoring can be derived in a relatively straight-forward manner. However, some values, such as the contribution to employment and income, can be difficult to assess.

The **intangible value** considers aspects that cannot be quantified in a conventional sense but which are very important in the assessment of priority. These can include information on the ecological value, social importance, and political significance. Values for such aspects are difficult to obtain and are frequently open to interpretation.

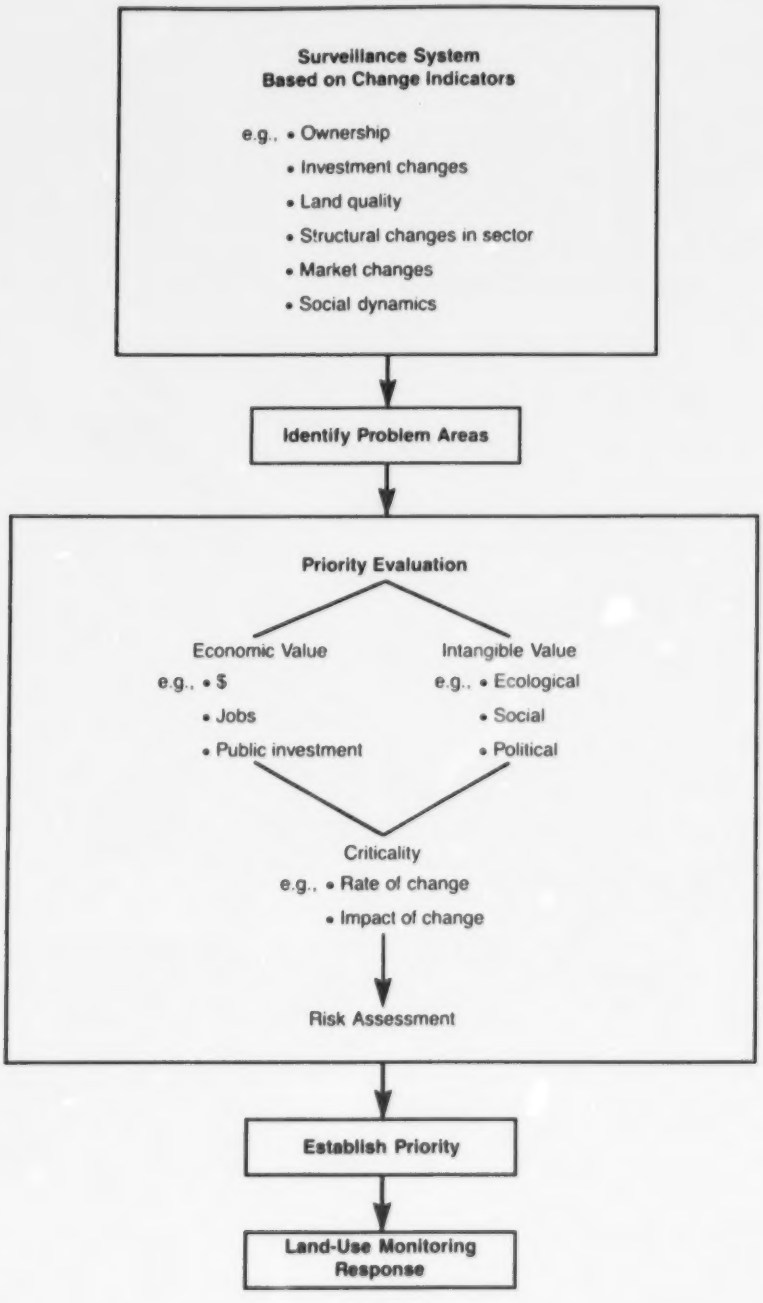
The **criticality of issues** concerns the urgency that may be required in initiating a monitoring response. This element of the decision-making process focusses on both the rates of change and the impact resulting from the changes which are occurring.

Setting priorities requires that all the necessary information and criteria be weighed against each other. The relative importance of one set of criteria versus another must be incorporated into the process. The group developed a **priority-setting model** to describe this process (*see* Figure 1).

Significant amounts of information have already been collected in land-use monitoring programs across Canada. These areas provide excellent barometers of land-use trends and should be used as such. However, information on these areas must continue to be timely and the period for updating should reflect changing priorities. This should permit monitoring of new priority areas.

As indicated previousiy, there is a perceived need to continue monitoring efforts in the rural-urban fringe. However, the information collected must be timely and the completion of urban-fringe studies should not be allowed to become too onerous to prohibit monitoring in other priority areas.

Figure 1
Priority-Setting Model



SUMMARY

Priority setting must be based on a systematic surveillance system based upon a set of change indicators. Arbitrary identification of priority areas is not possible. However, several candidate areas have been identified as priority areas requiring a land-use monitoring response. These are the Niagara region of Ontario, aggregate-producing areas, wetlands, and forest lands. Timely updating of areas currently receiving a monitoring response should continue, but flexibility should be built into monitoring programs to accommodate new priorities.

F. PRIME RESOURCE SECTORS OR ISSUES WHICH WARRANT A MONITORING RESPONSE

Chair: Doug Mazur
Rapporteur: Ken Redpath

Bob Huang
Jack Millar
Daniel Paquette
Dale Sudom
Michael Troughton

QUESTIONS ADDRESSED

- What prime resource sectors and or issues warrant a monitoring response?
- What are the criteria necessary to define and delineate prime resource lands of national significance?
- How can a monitoring program handle lands that may be important locally or regionally (e.g., wetlands, recreational land) but not considered prime on a provincial or national basis?
- Monitoring programs currently identify land-use changes; should they also encompass the analysis of inter-relationships between land and other socio-economic factors, for example between timber supply and alienation of the forest land base?

WORKSHOP DISCUSSION

The chairman opened this wide-ranging discussion by providing, as background, examples of resource conflicts in Saskatchewan.

Initially, in response to "what prime resource sectors issues warrant monitoring?" the answer appeared to be "all sectors and all issues". However, further discussion focussed on the reverse of the question; that is, "are there resource sectors and/or issues which do not warrant a monitoring response?" This, in turn, introduced a further set of questions deemed important for any monitoring program:

- What should be monitored?
- How should it be monitored?
- Who should monitor? and
- What use will be made of the monitoring information?

It was agreed that monitoring is required. Different sectors, however, require different forms of monitoring. Monitoring programs in Canada strive for an equal level of information for various sectors. The Canada Land Inventory (CLI) was identified as an attempt to achieve a standard information base for various resource sectors. However, more comprehensive background information for monitoring is required to use as a reasonable basis for decision making. It was suggested that the problem could be one of resource management and use, leading to the question "what is the limit of the use of the resource?" There was concensus that resources should be monitored where there is some threat to the particular resource. Specific resource sectors or issues requiring monitoring were not specifically identified. However, agriculture, forestry, and wildlife formed the basis of discussion.

Not surprisingly, in these times of budgetary restraint, the cost of monitoring was discussed. It was recognized that efficiency is needed in using existing information and that land-monitoring techniques must become more sophisticated. An interesting question which arose during the discussion was "are human resources a prime resource?" This question was posed in the context of convincing people that there is an economic value in monitoring.

Progress has been made in defining criteria for prime lands of national significance in specific resource sectors but not in relating and integrating the various sectors to each other to form comprehensive renewable-resource data bases. The group indicated that nationwide, the criteria for defining and delineating prime resource lands do not exist. It was noted, however, that national criteria had been established for the CLI program. The difficulty with national criteria is that resources may be important locally or regionally (e.g., class 4 agricultural land in Newfoundland) but may not be considered "prime" on a national basis. It was suggested that consideration should be given to establishing criteria at the local or regional level initially, followed by subsequent efforts to establish provincial and national criteria.

The group emphasized that monitoring must be as comprehensive and as consistent as possible on a systematic, temporal basis. The best example of a monitoring system to date in Canada was considered to be the Census of Canada. Information availability was identified as a problem. The monitoring process must have a stable information base. However, much existing information is located in the private sector to which access is either limited or unavailable, although in many instances this information was paid for by public funds, either directly or indirectly.

P.C. Rump

Landfill of a wetland area, National Capital Region, 1981

P.C. Rump

Landfill of a wetland area, National Capital Region, 1987

The interrelationships between resources should be stressed in monitoring programs. To set priorities, the dynamic interplay amongst the various sectors must be examined. In addition, flexibility is essential as priorities change.

SUMMARY

Although no specific conclusions and/or recommendations were reached, there was consensus that trends should be monitored where there is a threat to a particular resource. The information base for monitoring must be as uniform, comprehensive, and consistent as possible. Monitoring cycles should be systematic over time. Monitoring priorities must be established. However, because priorities change, flexibility is also required.

III

Methods and Techniques for Land-use Change and Degradation Monitoring

Papers
Workshops

THE USE OF AIR PHOTOGRAPHY FOR MONITORING LAND-USE CHANGE IN CANADA'S FRUITLANDS

Jean Séguin

In Canada, there are only a few areas where soils and climatic conditions are suitable for tree fruit and grape production. The Canada Land Use Monitoring Program (CLUMP) of the Lands Directorate, Environment Canada, has initiated a series of studies on land-use changes in the four major fruit growing areas in Canada: the Okanagan Valley, the Niagara Peninsula, the Annapolis Valley, and the St. Lawrence Lowlands. This paper discusses the methods by which land-use change information is obtained using black and white panchromatic air photographs. It describes the land-use change mapping procedures and the establishment of a geographic information data base, using the CLUMP fruitland studies as an example. This process is an essential element in analysing the implications of land-use change in the context of sustainable resource use.

INTRODUCTION

Land-use monitoring on a national scale is relatively new in Canada. Although the federal government has been collecting data and monitoring water resources since 1908, it was not until 1978 that Environment Canada established the **Canada Land Use Monitoring Program** (CLUMP). The objective of CLUMP is to monitor the amount, location, and type of land-use change on national and regional scales (Rump, 1983). Information derived from this program is used in predicting land-use trends, evaluating the impact of federal policies and programs on the land resource, national land budgeting, and regional and resource planning.

Canada's prime resource lands — lands with inherently unique physical qualities, location, or socio-economic features — are of particular interest to monitoring. These lands make a special contribution to the nation's economic, social, and environmental well-being and are often subject to land-use change pressures (Kerr, *et al.*, 1985). In 1981, the Lands Directorate of Environment Canada, under the Prime Resource Lands Component of CLUMP, initiated a series of studies to provide a national overview of the land-use changes and their significance in the major-fruitland producing regions of Canada.

Only a few regions in Canada have the combination of soils and climate suitable for growing tree fruits and grapes on a commercial basis. The four fruitland regions included in the CLUMP studies are: the Okanagan Valley in British Columbia, the Niagara Peninsula in southern Ontario, the St. Lawrence Lowlands south of Montreal in the Province of Quebec, and the Annapolis Valley in Nova Scotia. Although these regions are small, together they produce over 70% of Canada's tree fruits and grapes. The Okanagan Valley and the Niagara Peninsula produce the majority of the nation's tender fruits. However, over the last two decades, there has been increasing pressure on fruitlands from competing land uses. This is especially the case in the Niagara Peninsula and the Okanagan Valley where urban expansion and demographic growth have placed serious constraints on the availability of land for fruit production.

The purpose of this paper is to describe the methodology used by CLUMP to detect changes in land use on Canada's fruitlands. Researchers have employed a number of techniques to identify and measure land-use change using remotely-sensed source materials. With recent progress in remote-sensing

Proposed subdivision of Niagara fruitlands, Ontario

technology, it is expected that satellite imagery will play a greater role in land-use change research in the near future. However, the primary means of data collection to date in most operational projects under CLUMP is the use of black and white aerial photographs. Thus, the paper examines the role of aerial photography as a primary source of data capture for mapping land-use changes. It briefly describes the different techniques by which land-use changes are identified, mapped, and stored in a computerized geographic information system (GIS), the Canada Land Data System (CLDS) of Environment Canada. Results from these studies will provide an overview of the land-use trends in Canada's major fruit areas and should help to resolve some of the most pressing land-use problems facing these prime resource lands.

THE METHOD OF DATA BASE CREATION: CANADIAN FRUITLANDS

The major data acquisition and processing steps used in creating a geographic information data base for the fruitlands project are outlined in Figure 1. These steps can be divided into three major phases. First, the study areas are defined and land-use change information is gathered. Second, an automated geographic data base is created using the CLDS of Lands Directorate. Finally, the results are analyzed and published in the form of graphics, maps, and reports. Only the first two phases will be described in detail in this paper.

The CLUMP land-use classification system (Gierman, 1981), developed to ensure consistency and compatibility in monitoring projects across the country, was used in all fruitland study areas. This classification system allows for a maximum of two activity classes and two cover classes for any land unit or polygon. The activity classes represent the functional use that man makes of the land (e.g., agricultural, commercial, or dwelling use). The cover classes depict the actual vegetational or constructed covering of the land surface.

The land-use change data base for the Canadian fruitlands project covers three monitoring periods: 1961, 1971, and 1981. An extra land-use coverage, 1975, was incorporated for the Okanagan Valley to enable analysis of the impact of the Agricultural Land Reserves program on fruitlands. This program was implemented by the province of British Columbia in 1974.

Black and white panchromatic air photographs have been extensively used for resource management purposes in Canada since the 1920s (Mollard and Janes, 1984). For the fruitlands project, mapping was completed at a 1:50 000 scale using photographs with scales varying from 1:20 000 to 1:60 000. A window of three years — the monitoring year, one year before, and one year after — was established as acceptable dates for air photographs, depending on the availability, scale, and quality of photography.

Air Photo Interpretation and Transfer

Air photo interpretation was a crucial element in the process of mapping land-use changes in the fruitlands project. This is a difficult task that requires close supervision at different stages to ensure consistency in the methodology used and proper use of the land-use classification system to achieve accurate results. The time spent ensuring that the interpretation is accurate is an investment in the quality of the data. This also facilitates sound analysis from which important land-use trends can be revealed.

The 1981 air photographs were the first to be interpreted. This was undertaken in the regional offices of Lands Directorate located in Vancouver, Burlington, Ste-Foy, and Dartmouth, mainly under contract. For this monitoring period, field checks were conducted in complex areas to verify and, where necessary, update air photo interpretation. The 1981 land-use information is, therefore, likely to be more accurate than for the earlier periods. The 1971 and 1961 aerial photographs were then interpreted, using the completed 1981 land-use interpretation as a reference point when no other source of information was available. The same interpreters were used for all periods in order to ensure quality control.

Figure 1
CLUMP Data Acquisition and Processing Steps

In the interpretation process most polygons were assigned one activity and one cover. In areas of complex land use where subdividing would make a polygon smaller than the minimum size of 2.6 ha, a second activity and/or cover could be assigned. The first activity and cover always represented the dominant land-use characteristic within a particular polygon.

Two methods were used to transfer the land-use information from the photographs to map manuscripts at a scale of 1:50 000. The most common method employed a mechanical projection transfer device whereby the image was projected, matched, and registered with a National Topographic System (NTS) mylar base map. A *KARGL* projector, a *Zoom Transferscope*, and a *Stereo Zoom Transferscope* were used to transfer the information for fruitland studies in the Annapolis Valley, southern Quebec, and the Okanagan Valley. A different technique was utilized in the Niagara Peninsula study. Mylar overlays were placed on top of individual air photos and the land-use interpretations were recorded on them. These mylars were then built into a mosaic. The base map was reproduced, also on mylar, with its scale increased to match the mosaic. The adjusted base map was placed over the mosaic usually at the 1:25 000 scale. The adjusted base map was then placed over the mosaic and the land-use information transferred. Once transferred, the adjusted base map was reduced to the scale of 1:50 000 (Gallie, 1985).

Mapping Land-Use Changes

Milazzo (1980) has described four methods for detecting and mapping land-use changes. Each technique compares two sources of data — the interpreted aerial photographs and the land-use maps from the different monitoring periods. For the detection of land-use changes, the different techniques described by Milazzo compare:

- the original source material to the new source material (i.e., the 1981 interpreted air photographs and the 1971 interpreted air photographs);
- the original map to the new source material (i.e., the 1981 land-use map to the 1971 interpreted air photographs);
- the original map and source material to the new source material (i.e., the 1981 land-use map and the 1981 interpreted air photographs to the 1971 interpreted air photographs); and
- the original map to the new map (i.e., the 1981 land-use map to the 1971 land-use map).

SSC Photo Centre Library

Irrigation and fruitlands, Okanagan Valley, British Columbia

Northway-Gestalt Corporation

Gravel excavation in Niagara fruitlands, Ontario

Each technique has advantages and disadvantages. For example, the *KARGL* instrument has severe limitations when comparing photographs to photographs. The *Zoom Transferscope* and *Stereo Zoom Transferscope* are better designed for this particular task. Regardless of the technique employed, the main objective of this process is to detect "real changes" as opposed to "false changes". Even with strict quality control at the interpretation and transferring stages, inconsistencies caused by misinterpretation or by the poor quality of aerial photographs may be encountered.

The method used in this study was a combination of the first and fourth approaches outlined by Milazzo. Land-use changes were detected by overlaying the two land-use maps (e.g., 1981 and 1971) at the scale of 1:50 000. These were compared and the changes in land use between the two years were delineated on a separate mylar overlay. For each change polygon, the air photographs of both years were visually compared to confirm real change. Computer coding sheets were also completed at this stage. This procedure is very time consuming if the quality of the land-use change data is to be assured.

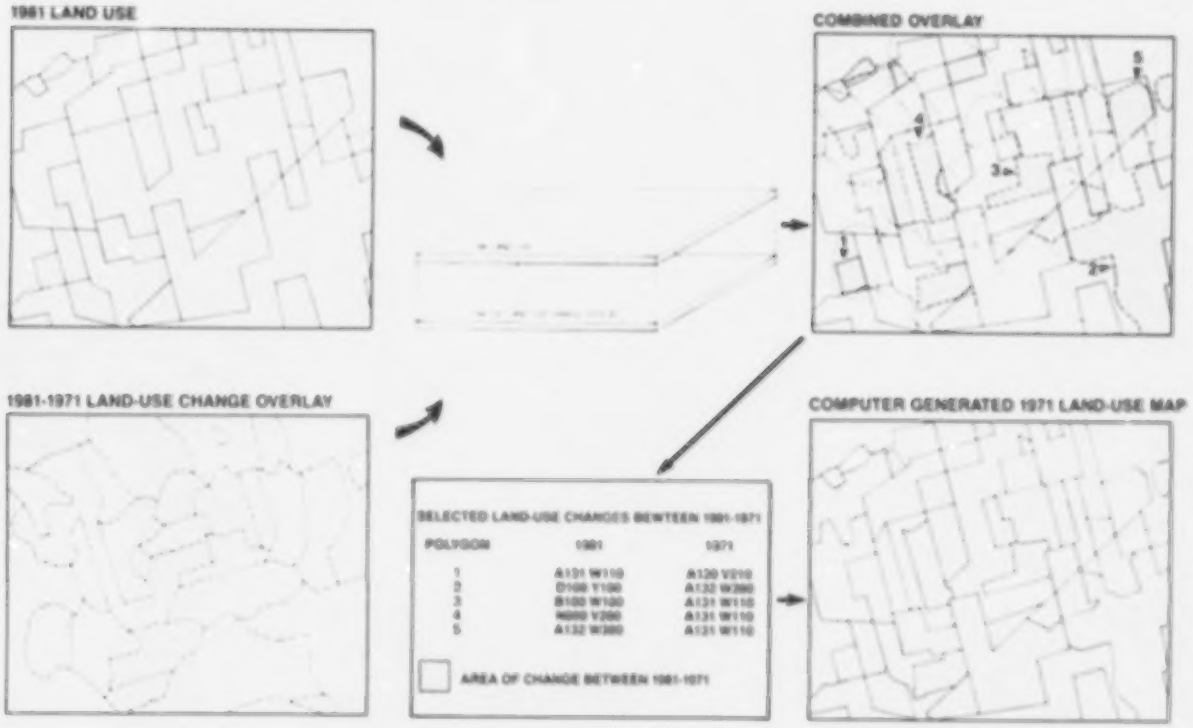
The land-use change overlay maps consisted of a series of polygons accompanied by computer coding sheets which provided instructions for the creation of derived land-use maps within the computer (*see* Figure 2). To eliminate problems associated with line weave[1], the lines drawn on the change overlay were exaggerated outside the original line. The areas where "no change" has occurred were not mapped on the change overlay.

Creation and Use of a Computer Data Base

The land-use information for the four fruitland studies was entered in the computer system of the CLDS. This system includes a large main frame GIS which has the capability to input, store, manipulate, overlay, and retrieve spatial information, and line and point data. In addition to the land-use infor-

[1]*See* I.K. Crain's paper, "Geographic Information Systems: Options for Monitoring" in this proceedings.

Figure 2
Land-Use Change Mapping in Canadian Fruitlands



mation, other maps were entered to create a more comprehensive data base to increase the potential for analysis. These additional coverages included Canada Land Inventory (CLI) agricultural land capability, federal lands, census sub-divisions, shoreline, and Agricultural Land Reserve boundaries (Okanagan Valley study area only).

The land use, land-use change, and other manuscripts and coding sheets were transformed into digital files stored on magnetic mediums such as disks or tapes (Gélinas, 1984). The maps were scribed and scanned using an optical drum scanner and the attribute data were entered into the computer system. To link the attribute data and the image data, a point was digitized inside each polygon of each map. The binary image data produced by the scanner were then converted to a vector file. A series of quality-assurance programs was then completed. These programs edit and update the image data and the attribute data. Errors such as missing lines between two polygons, misclassification due to coding errors, and two classifications inside one polygon, are then eliminated. All maps are edge-matched and linked to form one continuous land-use coverage for the complete study area.

CLDS has the capability of overlaying a series of different coverages to form an integrated data base. Once the overlay is completed and the data base ready for interrogation, a user can retrieve data by global retrieval capabilities or through terminals using interactive facilities. Through these terminals, users can selectively plot, generalize, and compile data on any or all of the overlayed data coverages and obtain statistical and graphic outputs.

CONCLUSION

To date, aerial photography has played a significant role in natural resource data acquisition, including land use. Aerial photography has proven to be the best available means of monitoring land-use change in the principal fruit-growing areas in Canada. Combined with the use of a technologically advanced geographic information system, aerial photographs have made it possible to fulfill the primary objective of monitoring land-use changes between 1961 and 1981 in the Okanagan and Annapolis Valleys, the Niagara Peninsula, and in the apple-growing areas of Quebec. By using a common land-use classification system and land-use change methodology, the Canada Land Use Monitoring Program provides a comprehensive land-use change data base for the major Canadian fruitlands.

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Response from the audience:

Ralph Krueger: As you know, I have been monitoring Canada's fruitlands for a long time. My question is, can I now relax and depend on you to monitor fruitlands in 1991? If we are going to have a true monitoring program, then we must update our information on a regular basis like the quinquennial census.

Jean Séguin: Now, for Canadian fruitlands, we have an automated data base and it will be relatively easy to add one more overlay for 1991. If the land-use change affecting fruitland continues, we will update our coverage. It is probable, however, that we will use satellite remote sensing products to determine the changes. In order to do this with satellite information, we will need greater precision in the separation of tree fruits from other small trees.

Unidentified speaker: How much of the land-use change information from the fruitland studies is being used by local municipalities in zoning by-laws? Is the information helping municipalities preserve fruitlands?

Jean Séguin: We have already contacted most of the regional planning and provincial renewable resource agencies in the Okanagan and Niagara regions. It is too early to determine if the information has been helpful to municipalities. However, we are committed to assist all agencies to understand the potential of such data bases and to apply the information to resolving local and provincial problems wherever appropriate.

SATELLITE IMAGERY FOR MONITORING LAND-USE CHANGE: STATE-OF-THE-ART AND FUTURE DIRECTIONS[1]

Robert A. Ryerson

After providing a brief historical perspective regarding the use of satellite imagery for monitoring land-use change, this paper discusses classification, visual update, and hybrid methods of mapping land use. Problems associated with remote sensing and monitoring, such as data continuity and user resistance, are reviewed as well as potentials and capabilities associated with the emergence of the micro computer as a monitoring tool. The relative costs of data acquisition are outlined and examples of local and regional applications of data are provided. In addition, an overview of some of the new satellite imagery data that is available today is included. The paper concludes that although higher resolution data will increase the use of remote sensing, as will the ability to interact with geographic information systems through micro computers, satellite and airborne imagery must be used with appropriate caution for land-use change analysis.

HISTORICAL PERSPECTIVE

Historically, land-use mappers have resisted using the products of satellite remote sensing, such as LANDSAT Multispectral Scanner (MSS) data, mainly because these data did not provide the type of information required. There was also a lack of data continuity in that one could not be assured of receiving the same type of satellite data over a number of years. Nevertheless, several methods have been used in the past to map land use from satellite images. These include classification, visual interpretation, and hybrid methods.

Classification

Classification involves the computerized analysis of data. The two ways of using classifications are:

- **inter-map comparison**; and
- **post-classification theme comparison**, using satellite imagery usually from the same source.

Both of these methods use a computerized overlay procedure to detect changes in land use. However, simple classification comparison involves comparing a land-use map from one date, usually drafted by hand from the interpretation of aerial photographs, with a similar map derived in the same fashion from another date. These maps, usually from different sources and classified by different interpreters, are superimposed and land-use changes recorded using a geographic information system (GIS).

The second approach uses satellite digital data or imagery from two separate dates. Information from the two periods is combined in an image analysis system and land-use themes are overlayed to indicate where change has occurred. Although the accuracies of both approaches are comparable, the multitemporal method using satellite imagery is more cost-effective and guarantees compatibility of classification information. A simpler method combines information from two dates, and assigns different colours to the information from each. This method was described first by Banner and Lynham (1981) for a forestry change application (mapping forest cutovers). These general approaches are described by Ryerson, *et al.* (1982).

Visual Interpretation

Using a device called *Procom-2*, maps can be visually updated by projecting a satellite photograph through a lens, onto a mirror, back down to a table on which it is easy to work.[2] It is also possible to link the *Procom-2* to a digitizer to provide

[1]This paper was prepared for and edited from an oral presentation accompanied by a number of photographic examples. These examples could not be reproduced in the proceedings and the text has been edited to remove the detailed discussion. The reader is invited to consult the sources noted or to contact the author.

[2]Details on this instrument may be obtained from the manufacturer, Gregory Geoscience Ltd., 1794 Courtwood Crescent, Ottawa, Ontario K2C 2B5.

digitally compatible information. This approach is similar to using a zoom transferscope (ZTS) for land-use updating. However, unlike the ZTS, this lower-cost instrument allows comfortable use for hours at a time. The *Procom-2* has proven to be very efficient for updating maps including all the 1:250 000 National Topographic Series (NTS) maps of Canada.

Hybrid Methods

Hybrid approaches are more flexible because they employ an instrument such as the *Procom-2* in combination with digital image analysis or the digital manipulation of data in a geographic information system to provide a better end-product. In effect, the human mind is combined with the power of computers to overcome some of the limitations of computers regarding pattern recognition, and the limitations of the mind with respect to repetitive tasks. This is particularly important with new types of data which inherently present problems. With new, more detailed information, for example, instead of seeing a forest as a generalized entity with information averaged over 80 m, the resolution is now 30 m. With the Système Probatoire d'Observation de la Terre (SPOT), a 10-20 m resolution is possible. We are, therefore, at the point where actual trees, tree shadows, and other such details become visible. In addition, with more detailed spatial information, there is a loss of homogeneity. The visible detail, combined with the lack of homogeneity, results in some confusion for the classical methods of digital image manipulation. It is difficult to know if the sun is rising on a whole new technology or whether the sun is setting on the older technology.

Examples of hybrid approaches include applying digital and visual analysis to a problem, organizing the results in an updated GIS, and then using the results in an application. In some cases digital image analysis may not be indicated. The hybrid approach may simply use a visually-based instrument linked by a digitizer to a GIS and then, apply the updated information in the GIS to the problem at hand. This last approach has certain attractive features, not the least of which is the cost and simplicity of the equipment involved.

DATA CONTINUITY AND USER RESISTANCE

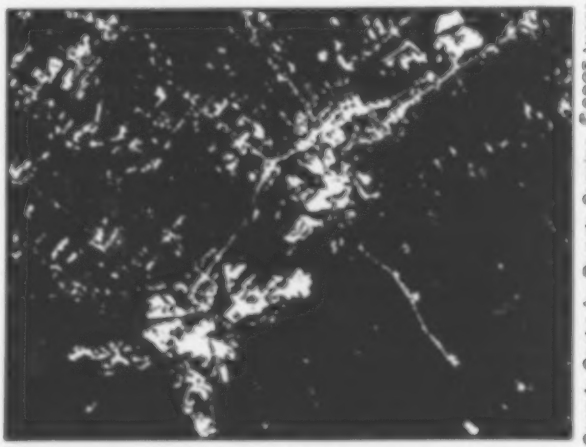
Since many people thought that LANDSAT was simply a research program with a continuing data supply being uncertain, they were reluctant to invest in the infrastructure needed to handle **satellite information**. This idea has been dismissed with the signing of a contract between the U.S. Department of Commerce and the Earth Observation Satellite Corporation (EOSAT) to provide two more satellites in the LANDSAT series. Thus, access to satellite information should be guaranteed for years to come. As well, SPOT is launching its satellite in early 1986[3], and has two more satellites in the planning stages. By 1986, it will be known whether or not RADARSAT will be approved for launch in the 1990s[4]. This Canadian satellite will have a 30 m resolution visible sensor, a 25 m resolution radar sensor, and other instruments for use on more global-type studies. The data continuity problem with respect to satellite data has been laid to rest.

[3]Successfully launched on February 21, 1986.

[4]RADARSAT was approved for launch on June 25, 1987.

Aerial photography is one area of remote sensing that has been routinely used by land-use specialists for many years. Black and white aerial photography has become the standard interpretation medium for much of the land-use data currently available in Canada. However, there has been some user resistance to the more exotic **colour** and **colour infrared** aerial photography in the land-use community. While such imagery is more expensive to acquire than black and white imagery, colour images have proven easier and faster to interpret with more information available at smaller image scales. Even if new colour photography is custom-flown, the cost savings associated with an entire land-use mapping program make it less expensive than purchasing and interpreting black and white aerial photography from archives such as the National Air Photo Library (NAPL). The Edmonton Regional Planning Commission, among others, have documented these savings for a cost-benefit analysis performed by the Canada Centre for Remote Sensing (CCRS) (Ryerson, 1981).

When comparing colour aerial photography acquisition costs to those of high resolution satellite photos (Thematic Mapper data at 30 m), the aerial photography is about 240 times more expensive to cover an area of 10 000 km^2. Digital satellite data costs 1/25 as much as the colour aerial photography. For land-use mapping, then, satellite images should be preferred where they can provide the information. Where satellite imagery is not feasible, colour aerial photography should be used.



Canada Centre for Remote Sensing, © SPOT Image

Open-pit mining, Thetford Mines, Quebec

MICRO COMPUTERS

In 1982, sales of micro computers in Canada amounted to approximately $200 million wholesale. In 1984, it was $885 million, while in 1985, it is expected to be $1 billion. IBM has 73% of that market. With this in mind, it seems reasonable to suggest that people will look to the IBM PC micro computer, for example, as the basis for future developments in remote sensing image analysis at the local level. Such systems are already being manufactured and sold in Canada. A micro computer system may be used with a display together with visual analysis, or used to link a visual system to a GIS. It is possible to do the traditional type of classification with images and then mod-

ify these interactively. Many capabilities exist today with micro computers. CCRS is presently releasing a request for proposals by industry to provide digital images on a floppy disk (FD) medium for use in micro computers. Townships will be able to buy an FD for their area and then process it, either on their own system, or on one at a nearby consulting engineering firm. In the near future great surges of applications are expected. One projection states that by 1988 there will be 150 such micro computer systems in regional government and planning authorities' offices in Canada alone.

APPLICATIONS

Local Data

For many local applications, for example municipal mapping requiring specific details on land use for either base mapping or updating, it is expected that **colour** or **colour infrared** air photos will remain the only appropriate source of information for some time. Where more generalized information is required, or where it is desirable to identify areas of change, **satellite imagery** shows considerable promise — even at the local level. Studies and contract mapping completed by Gregory Geoscience Ltd. have clearly demonstrated this capability (H. Moore, pers. comm.). All possibilities of local applications of satellite technology have not yet been thoroughly documented. Users should, therefore, proceed with caution.

Regional Data

Imagery from the lower resolution **MSS** (80 m) has been used by the Lands Directorate, Environment Canada to integrate land-use and land-cover data with other environmental factors for all of Canada. This program, and others, have demonstrated the usefulness of even the older satellite data for providing a regional perspective.

The higher resolution LANDSAT **Thematic Mapper** (TM) imagery provides an even better perspective. Transportation routes, aggregations of buildings, etc., are clearly discernible. It should be noted that the colour infrared transparency format is recommended when TM photo products are being used. The utility of satellite imagery is higher where mapping has never been done before or has not been done recently (such as in developing countries). In such cases, a range of potential land applications would include:

- identifying areas of change for further study using aerial photography, thereby reducing the amount of costly photography required;
- mapping specific easily-recognizable change features over a large area such as wetlands, water bodies, crop condition or weather damage, irrigated land, forested areas in agricultural zones; and
- mapping general land-use/cover change over large areas.

Users should also consider the feasibility and cost implications of collecting information through **sampling** using, for example, specially acquired **70 mm aerial photography**, or even sampling from a **satellite photograph**. Such a procedure is one of several options being evaluated for rural-land change mapping in Canada by the Lands Directorate. Several hundred 1.5 x 4.5 km samples were interpreted in Manitoba in 1984 at a scale of 1:40 000 using colour infrared photographs. The image acquisition cost was under $15 000.

At this early stage of applications development and assessment, users should proceed with caution and with an open mind. The nature of satellite imagery is such that certain features at detailed levels of land-use or land-cover classifications are easily discernible, while other features at the same scale are not. Furthermore, what is possible in one region of Canada may not be possible in another where different soil types, survey patterns, crop types, and field sizes may be found.

CONCLUSIONS

Remote sensing has already proven useful in a variety of land-use change studies where it has been applied carefully, with due consideration given to its limitations. Higher resolution data and the ability to interact with a GIS through micro computers will increase the use of satellite remote sensing. However, satellite and airborne remote sensing will not be an informational panacea for those interested in land-use change. Both types of sensing carry with them certain positive and negative attributes. Where the limitations are ignored, failure and disappointment will result. Where these attributes are carefully assessed, and an appropriate procedure is selected, remote sensing can be a powerful tool.

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Response from the audience:

Gordon Weetman: What is the cost of conventional aerial photography?

Robert Ryerson: Conventional colour aerial photography costs approximately $2.40 per km². LANDSAT TM data in the standard full image format costs approximately 1¢ per km² for a photographic product and approximately 10¢ per km² for a digital product. Costs for floppy disk products are substantially higher per unit area, but it is not usually necessary to cover a large area. It has been estimated that floppy disks for a township would cost between $50 and $100. This is a preliminary estimate; industry will decide what the price will be.

Acquisition costs for black and white photography are 30% to 40% lower than those for colour photography. However, interpretation speed is approximately doubled when colour photography is used. Therefore, in the long term the use of colour is more efficient. A paper entitled *Results of a Benefit Cost Analysis of the CCRS Airborne Program* (Ryerson, 1981) provides details of costs and findings of users in the planning environment regarding the most efficient methods for doing various types of interpretation.

Richard Mussakowski: What level of expertise is required by a local municipality to effectively use micro computers?

Robert Ryerson: Since micro computers are very user-friendly, I expect that people will only have to take a three-day course on using a system, and then spend one or two weeks gaining trial and error experience. In addition, since people are already familiar with photo and image interpretation, it will be much easier to make a land-use planner into a photo-interpreter than vice versa. I do not foresee many problems with this, particularly with the level of computer-knowledge people have today.

David Wilson: Regarding SPOT and other satellite systems, many thousand megabytes of information require a very large system. Is CCRS considering marketing for local municipalities subsets of one, two, or three km²?

Robert Ryerson: Although there are many megabytes of data, the resolution is so fine that the algorithms to interpret it with computers have not yet been developed. Therefore, it is usually interpreted visually. One way of handling the data is simply to buy a visual image and display it on a display system. I doubt that CCRS will ever package satellite data into 1 km² areas, although this remains to be seen. Perhaps 15 to 20 km² is more feasible since this conveniently fits into a floppy disk. These probably will be marketed by the private sector by next summer. If there is a market for it, industry will do it. However, I suspect that we will ultimately be going toward optical disks.

THE USE OF THE ASSESSMENT ROLL TO DETERMINE URBAN LAND-USE CHANGE IN THE PROVINCE OF QUEBEC

Robert Cournoyer

In response to the Land Use Planning and Development Act (1979), a land-use mapping program was created to provide an overview of urbanization in Quebec. Ninety-one agglomerations comprising 80% of the province's population were mapped and a weighing method used to obtain the area of specific land uses at a scale of 1:20 000. Results indicate that much suburban growth is occurring at the expense of prime agricultural land. In agglomerations with populations between 25 000 and 99 999, the area of urbanized land increased more than 85% between 1966 and 1979.

To continue the land-use program in a time of increasing budgetary constraint, it was appropriate to evaluate existing data sources. The real estate assessment roll was considered a suitable monitoring tool. Advantages include lower costs, availability of comparable data for all Quebec municipalities, an annual production cycle for updating purposes, data accuracy, and the elimination of manual, area calculation.

INTRODUCTION

The 1970s were marked by disorderly land-use change in Quebec. With uncontrolled urban growth on the increase, the need for regulation became more urgent. Consequently, Bill 12 (*The Act Respecting Municipal Land Use Planning and Development*) was introduced in 1976. Although it was never passed, it suggested that urban area councils be created and that they prepare management plans. Finally, the *Land Use Planning and Development Act* came into effect in 1979. This Act went beyond Bill 12 by creating regional affiliations of municipalities. The new administrative structure was known as the **Regional County Municipality**, or RCM. Each RCM is required to prepare a management plan. Once such plans are adopted, each municipality must tailor its land-use by-laws to comply with the regional management plan. In support of the Act, the Quebec Municipal Affairs Department introduced a land-use mapping program in 1979.

THE LAND-USE MAPPING PROGRAM

In 1979, land uses in urban or urbanizing areas were mapped for 91 agglomerations. This mapping included 376 regrouped municipalities inhabited by 80% of the population of Quebec. Production of the land-use maps and the planimetric data generated by them occurred between 1966 and 1979 for most of the agglomerations. A 1981 updating was also completed for 22 agglomerations located in the metropolitan regions of Montreal, Quebec City, and Chicoutimi-Jonquière. This dynamic element provides an opportunity to observe urbanization during a very active land development period.

In the present context, **agglomeration** applies to a grouping of at least two municipalities having a total population of 5 000 or more, and having at least one central urban entity and one suburban or satellite urban entity, and where the intervening zone of rural land use does not exceed 2 km. This definition, based on continuity of urbanization, differs from that of Statistics Canada (1981) which defines a census agglomeration as:

1. the main labour market area of an urbanized core (or continuously built-up area) having between 10 000 and 99 999 population, and
2. municipalities completely or partly inside the urbanized core and other municipalities if
   a) at least 40% of the employed labour force living in the municipality works in the urbanized core, or
   b) at least 25% of the employed labour force working in the municipality lives in the urbanized core.

Under the Quebec program, 13 agglomerations within the urbanized zone of greater Montreal have been identified, whereas for the purposes of Statistics Canada, the Montreal Census Metropolitan Area (CMA) constitutes a single, larger agglomeration.

PREVIOUS METHODOLOGY

With the limited resources available, it was not feasible to conduct a field survey covering the total land area of 376 municipalities. Consequently, air photo interpretation was used. All of the information was converted to a common scale due to inconsistencies of photographic scale. For final map production, a scale of 1:20 000 was used because:

- the availability of cadastral and topographic maps at a scale of 1:20 000 meant greater graphic precision;
- it is a scale appropriate for the preparation of management plans for RCMs; and
- it is compatible with less detailed land-use mapping which requires some generalization.

Within the context of this program, the term **land use** is applied to the urban environment and refers to the actual use of the land.

The interpretation of aerial photographs is subjective. To ensure consistency, the various land-use categories were defined, illustrated, and indexed. Six categories of land use were used: residential (low, medium, and high density; mobile home parks); commercial; industrial (extraction, manufacturing); public services; communications; and green spaces (parks, golf courses, ski areas, holiday resort areas).

Due to the difficulty encountered in measuring many types of land use, diverse in both their nature and cover, a seldom-used method was employed; namely **weighing**. A paper copy of the map was cut and grouped according to land use. The weight of each land-use type was then determined using a scale accurate to 1/10 000 gm. By multiplying the result by a constant, the area of land occupied by a specific land use was obtained. This method has been assessed as 97% accurate and is clearly superior to the polar planimeter or dot-square matrices. The final margin of error observed in the Quebec program was between 5% and 10% when compared to actual land use. This margin was considered acceptable, given the constraints associated with final map scale, and the primary aim — to provide an overview of urbanization in Quebec with as much accuracy as possible.

RESULTS

Land-Use Maps

The land-use maps delimit the various land-use categories and sub-categories. In addition, they provide information such as the boundaries of the city centres, the main energy transportation routes, etc. Among the main users of the maps are the municipalities and RCMs, engineering and urban planning offices, government departments and semi-public agencies (such as Hydro-Quebec), and educational institutions — universities in particular. The maps may also be used in environmental impact studies. However, lack of map updating has lead to a decline in demand.

Area Calculations

Data produced by the weighing method consider six major land-use categories and are available for three time periods — 1966, 1976, and 1979. Information for 1981 is available for 22 agglomerations. Based on this data, several analyses were prepared. Table 1, for example, shows aggregated data for Quebec agglomerations with populations greater than 5 000. In agglomerations with populations between 25 000 and 99 999, the urbanized area has increased more than 85% in 13 years.

Table 2 shows the change in the urbanized area for the major units centred on the city of Montreal. The Montreal Urban Community (MUC) in this context corresponds to one agglomeration. By adding the 12 other agglomerations in the urban ring surrounding greater Montreal, the area (with the exception of three small municipalities) covered by the CMA may be obtained. This table reveals that more active growth is occurring in suburban areas than in the centre of the CMA. Suburbanization has taken place at the expense of some of the best agricultural land in the province.

The type of land-use data available, using the municipalities of Ste. Foy and Charlesbourg as examples, is shown in Table 3. The data outline the functional structure of each municipality. A balance of land uses was maintained between 1966 and 1981 in Ste. Foy, whereas the single-function bedroom suburb nature of Charlesbourg was accentuated over the same period. Differences observed in these land-use structures can be

Table 1
Changes in Urbanized Areas by Size of Agglomeration, 1966, 1976, 1979

Class (Number of inhabitants)	1966 (ha)	1976 (ha)	1979 (ha)	1966–1976 (% change)	1976–1979 (% change)	1966–1979 (% change)
> 100 000	64 486	83 383	96 650	29.3	15.9	49.9
25 000 – 99 999	36 548	55 508	68 606	51.9	23.6	87.7
10 000 – 24 999	17 626	24 169	29 977	37.1	24.0	70.1
5 000 – 9 999	8 231	11 272	14 916	36.9	32.3	81.2
Total	**126 891**	**174 332**	**210 149**	**37.4**	**20.5**	**65.6**

Source: Areal data on the urban functions of agglomerations in Quebec (1966, 1976, 1979), Department of Municipal Affairs, 1981

Table 2
Changes in the Urbanized Portion of Montreal Municipalities, 1966, 1976, 1979

Administrative Unit	1966 (ha)	1976 (ha)	1979 (ha)	1966–1976 (% change)	1976–1979 (% change)
Montreal (City of)	**13 354**	**13 982**	**15 666**	**4.7**	**12.0**
Other municipalities in the MUC*	16 893	20 734	24 015	22.7	15.8
MUC*	**30 247**	**34 716**	**39 681**	**14.8**	**14.3**
Other agglomerations in the CMA**	24 320	38 308	45 722	57.5	19.4
CMA**	**54 567**	**73 024**	**85 403**	**33.8**	**17.0**
Other agglomerations in admin. region 06***	16 578	22 839	31 688	37.8	38.7
Region 06***	**71 145**	**95 863**	**117 091**	**34.7**	**22.1**

* Montreal Urban Community
** Census Metropolitan Area
*** This is the greater Montreal administrative region. There are 10 administrative regions in the Province of Quebec
Source: Areal data on the urban functions of agglomerations in Quebec (1966, 1976, 1979), Department of Municipal Affairs, 1981

Table 3
Land-Use Classification for Ste. Foy and Charlesbourg, 1966 and 1981

Municipality	Land Use	1966 Area (ha)	1966 Proportion (%)	1981 Area (ha)	1981 Proportion (%)
Ste. Foy	Residential	1 019	40.9	1 223	42.2
	Commercial	200	8.0	227	7.8
	Industrial	100	4.0	188	6.5
	Public	308	12.4	373	12.9
	Green Spaces	125	5.0	152	5.2
	Communication	737	29.7	737	25.4
	Total	**2 489**	**100.0**	**2 900**	**100.0**
Charlesbourg	Residential	895	72.9	1 521	77.3
	Commercial	93	7.6	121	6.1
	Industrial	42	3.4	58	2.9
	Public	172	14.0	204	10.4
	Green Spaces	26	2.1	64	3.3
	Communication	0	0.0	0	0.0
	Total	**1 228**	**100.0**	**1 968**	**100.0**

Source: Areal data on the urban functions of agglomerations in Quebec (1966, 1976, 1979), Department of Municipal Affairs, 1981 (updated, 1982)

explained by their geographical position within the Quebec Urban Community, political decisions, and other factors.

The significance of data on land converted to urban uses can be illustrated using data in Table 4. The amount of space still available for development can be determined by subtracting the urbanized area and the zone of permanent agriculture (green zones) from the total area. (Green zones were established on implementation of the *Act to Preserve Agricultural Land* (1978) to protect land for agricultural purposes.)

Table 4
Urbanization Rate of Selected Municipalities, 1979

Municipality	Population*	Total Area** (ha)	Urbanized Area*** (ha)	Green Zone**** (ha)	Residual (%)
Montreal	1 045 000	15 966	15 666	0	**1.9**
Quebec	174 900	8 943	3 649	558	**53.0**
Sherbrooke	74 600	5 542	2 581	546	**43.6**
Outremont	26 200	367	367	0	**0.0**
Joliette	16 800	2 175	919	484	**35.5**
Gaspé	16 800	94 928	517	0	**99.5**
Beloeil	17 000	2 400	701	1 574	**5.2**

Source: * Quebec Bureau of Statistics, 1979
** Repertoire administratif des municipalités du Québec, Department of Municipal Affairs, 1981
*** Areal data on the urban functions of agglomerations in Quebec (1966, 1976, 1979), Department of Municipal Affairs, 1981
**** Quebec Agricultural Land Preservation Commission, 1981

A NEW METHOD

Due to budget constraints, it is not possible to conduct a new land-use mapping and data program identical to that carried out for the period 1978-1982. To continue to supply data on urban land use, it was appropriate that new technologies and automated data sources be considered. An existing source of data was identified — the real estate assessment roll. The **assessment roll** is an administrative document which forms the basis for municipal taxation in Quebec. Each municipality is responsible for the preparation of its own assessment roll, as prescribed by the *Municipal Taxation Act* (1979). The regulations assure uniformity and homogeneity of the roll, thereby making it a suitable tool for comparing municipalities.

The assessment roll contains information on each property located within a municipality including the name and address of the owner, lot dimensions, number of housing units, number of storeys, building value, and the land-use code. In the case of multi-purpose buildings, the predominant use is recorded. The land-use code refers to a classification based partly on that used by the Quebec Bureau of Statistics for economic activities, and partly on the *Standard Land Use Coding Manual* (United States Department of Transportation, 1969). The eight land-use codes for land-use mapping presented in Table 5 were derived from the 4 000 codes used in real estate assessment.

In 1986, the Quebec Department of Municipal Affairs will have the municipal assessment rolls in a single computerized format. With easy access to these assessment roll records, it will be possible to continue the land-use program. Abstracting the relevant variables included in an assessment roll and processing the data pose few technical problems. Advantages include lower costs, availability of uniform and comparable data for all municipalities, an annual production cycle for updating purposes, data accuracy in the order of 99.9% due to exact land-area data, and the elimination of manual, areal calculation.

Although spatial representation of the data is possible, there are some problems associated with the production of the land-use maps which must be overcome. After numbering a cartographic document such as the graphic matrix (the obligatory identification and classification system for assessment units), the results could conceivably be displayed directly by means of a plotting board. This is possible because of the serial number assigned to each assessment unit, based on a modification of the x and y coordinates of the Modified Transverse Mercator grid. Efforts are currently concentrating on verifying the feasibility of the technology. In order to test hypotheses, a limited pilot project has been proposed. Costs are a very important factor and will guide future activities.

Pilot Project

An **alpha-numeric data bank** was compiled from records of 16 variables extracted from the Longueuil assessment roll which comprises approximately 22 000 assessment units. The variables extracted included the reference number, the neighbourhood unit, the update code, the address of the real property, the land-use code, the type of ownership, class of building, date of construction, number of housing units, number of

SSC Photo Centre Library

Mirabel Airport, Quebec

Table 5
Codes for Land-Use Mapping

1 Residential	• Low density • Medium density • High density • Mobile homes
2 Commercial	• Wholesale • Retail • Service • Recreation
3 Industrial	• Extraction • Processing
4 Community	• Government • Religious • Educational
5 Transport and Communications	
6 Green Spaces	
7 Agricultural	
8 Residual Spaces	

Table 6
Land-Use Classification, Sample Study Area

Land-Use Classes	Units	Hectares (ha)
Total Residential	**296**	**16.6**
• Low density	187	9.4
• Medium density	59	3.0
• High density	20	2.2
• Cases to be categorized*	30	2.0
Total Commercial	**45**	**11.7**
• Retail	27	3.2
• Service	17	2.9
• Recreation	1	5.6
Total Industrial	**1**	**0.0**
• Processing	1	0.0
Total Community	**1**	**1.3**
• Religious	1	1.3
Total Transportation and Communications	**1**	**2.6**
Total Residual Space	**12**	**0.7**
Total	**356**	**32.9**

* These 30 cases will be shared between medium and high density residential. More criteria have to be defined before they can be assigned to a sub-category

storeys, frontage, area, value of the building, value of the lot, and value of the real property. A **graphic data bank** was created based on a list of 356 assessment units (properties) in a sample study area. Use of these data banks is supported by SPSS-PC and AutoCAD software, as well as by several smaller programs used to interconnect these various components.

Data was processed in a micro computer with a rigid 10 mg disc operating autonomously without central computer hookup. The results obtained cover a small data base because of the memory capacity required, especially for graphic display. Nevertheless, this is a secondary consideration in that a larger scale will also work given the required memory capacity and adjustments. The use of microprocessors in this project is intended to demonstrate to smaller municipalities the possibility of processing several variables on the assessment roll for planning and urban management purposes. With regard to conventional, computerized data-processing, results for various aspects of land use can be produced with little difficulty as shown in Table 6.

It is possible to prepare a graphic display of the land-use map for the 356 assessment units. Figure 1 illustrates applications using a dot symbol; an overlay could also be used for this purpose. Moreover, it is also possible to produce urban environment indicators, such as the category of housing density per ha for each residential assessment unit, the tax value of the property (building and lot) per m^2, etc. These examples indicate the kinds of applications that could be derived from assessment roll data.

The information obtained is precise. Consequently, generalization is necessary if a map is to be produced at a scale of 1:10 000 or 1:20 000. This suggests a minimum-size area restriction is required for grouped variables.

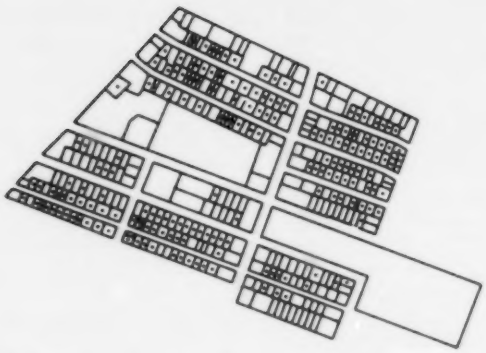
Problems relating to the **selection of criteria** from the data base used for the display of land use at a small scale have not been overcome and await software development. The next concern will be to address the memory constraints affecting the organizational and functional structures, with the intention of introducing such a system to the municipal environment. With such tools, municipalities should make greater use of the data contained on assessment rolls for management and planning purposes.

SUMMARY

In response to the *Land Use Planning and Development Act*, a land-use mapping program was created to provide an overview of urbanization in Quebec. However, to continue to provide land-use data during the present times of budgetary constraint, it is necessary to consider the use of existing data sources. Computerization of assessment roll data is being used to provide current land-use and land-use change information in Quebec.

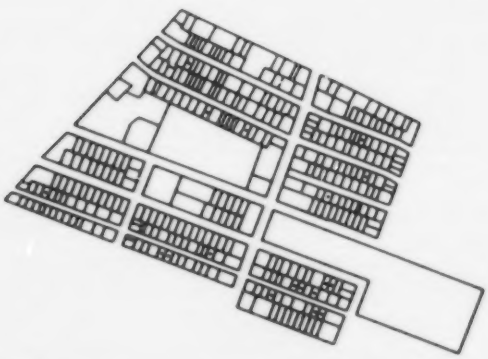
Robert Cournoyer is Director, Research and Policy Branch, Quebec Department of Municipal Affairs.

Figure 1
Sample Study Area, City of Longueuil, Province of Quebec

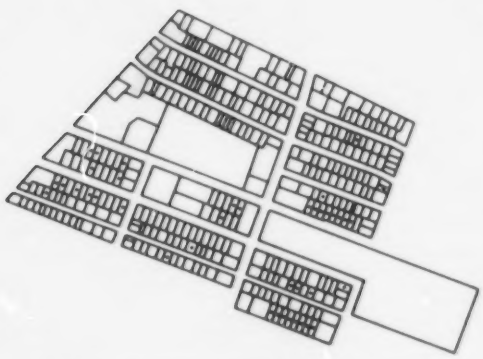


A Low density residential

B Retail establishments



C. Medium density residential:
61-84 housing units / ha



D. Medium density residential:
Tax value: $ 115 - 169 / m^2

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Response from the audience:

Michel Melançon: You have provided examples of urban area land-use maps which have been created using assessment rolls. Are you going to map land-use information in rural areas, on a farm of 100 acres, for example? If so, how do you propose to do this?

Robert Cournoyer: This does not lie within the responsibilities of the Quebec Department of Municipal Affairs. Local planning is now within the jurisdiction of the Regional County Municipality (RCM). On the assessment roll, rural land uses are identified at a very general level, for example, "farm". The assessor does not go to the fields to determine that there are 50 acres of pasture and 50 acres of corn on a 100-acre farm, for example. The assessor is neither an agronomist nor a crop specialist. Although this may affect the assessment, this level of detail is not considered in compiling the assessment roll. If the local or regional government needs this information, a specialist may be hired to map the land use of the area since the assessment roll is based on geographic references (NTS).

THE APPLICATION OF SAMPLING TO LAND-USE MONITORING

Christopher R. Bryant

This paper suggests that probability sampling approaches may only be appropriate for certain types of land-use monitoring. It is argued that the effective use of probability sampling requires some prior knowledge of the phenomena being monitored. Different combinations of objectives and types of monitoring will influence the conclusions on the appropriateness of selected types of sampling strategy. In only one case, that is, following "known" changes in order to provide estimates of the magnitude of change, is consideration of probability sampling approaches clearly indicated. In other situations, a system involving representative areas, and what have been called regional observatories, is suggested as being more useful.

INTRODUCTION

When compared to complete census of a statistical population, the sampling approach to land-use monitoring seems to offer a number of attractive features including cost and timeliness. Sampling approaches to land-use monitoring have been reviewed elsewhere (Bryant and Russwurm, 1983); hence, no attempt is made here to review the various methods and their relative advantages and disadvantages. Rather, the objective of this paper is to identify for discussion purposes one of the most important problems in using sampling for land-use monitoring. Specifically, the argument is made that **probability sampling** may only be appropriate for certain types of monitoring because of the importance of prior knowledge about the phenomena under study for the selection of a sampling design. Furthermore, given the coarseness of many land-use classification systems, even complete systematic coverage for purposes of general land-use monitoring is not necessarily appropriate for monitoring.

Before developing this argument, a number of general points regarding sampling and land-use change need to be emphasized. First, there are many different sampling schemes possible, ranging from the various types of probability sampling methods to judgmental sampling. However, all sampling approaches share in common the purpose of allowing us to comment about a broader population by focussing data collection and observation on a subset of that population. Major considerations involved in the decision to sample rather than to undertake a census or complete coverage of the population include: lower cost of sampling; greater timeliness in producing results; and greater accuracies afforded by permitting greater concentration of effort on the all-important task of classification and measurement. Second, land-use change is a complex phenomenon. It touches on a whole host of dimensions including "what", "who", "for whom", "how", "where", and "when" questions (*see* Table 1). The complexity of the issues involved in land-use change, and the data needed to help answer those questions immediately suggest that it is unlikely that any single approach to data observation and collection will be sufficient.

Table 1
Dimensions of Land-Use Change

Dimensions of land-use change	Type of question involved*
Land cover Land-use activity Land quality and biophysical attributes of land (and impacts on these attributes)	"What" questions
Tenure and organizational structure (e.g., farm size, family-based structures, etc.)	"Who", "for whom", and "how" questions
Levels of applications of capital and labour to the land	"How" questions

* All questions involve "where" and "when" questions too

In **land-use monitoring**, interest focusses on three major sets of questions. First, of major concern is the location and timing of land-use changes. Second is the importance of the changes observed — a "so what" question — in terms of economic, political, social, and environmental concerns. Finally, monitoring implies concern for the future — under what conditions are certain land-use changes likely to occur, and how important

will they be in terms of decision making? This third set of questions poses perhaps the most fundamental problem, that of acquiring information on the **relationships that exist between the land-use changes** of interest and the other dimensions of the environment that give rise to the land-use changes.

In light of this complexity, what in fact are the goals and objectives of land-use monitoring and how can it be characterized? It is suggested below that two types of monitoring and two sets of objectives for land-use monitoring can be identified. The key argument is that different combinations of these are associated logically with different conclusions about the role of sampling strategies.

TYPES OF MONITORING AND MONITORING OBJECTIVES

The two types of land-use monitoring that can be identified are following or tracking "known" changes; and the detection of new change. In **tracking "known" changes** attention is focussed on changes about which a body of knowledge and understanding already exists. Included in such monitoring would be certain types of man-induced changes such as urban growth, and natural changes such as seasonal vegetation variations. Such phenomena could be monitored both throughout a national territory or for areas of special significance using various sampling strategies, although differing scales of problems and processes may necessitate complex designs.

In the **detection of new change** attention is focussed on being able to detect changes in land use and its attributes not previously recorded in a given region. This type may also involve the detection of change that is "known" in some other geographic and temporal context, but that has not yet been observed in the particular region under scrutiny. At least some knowledge already exists regarding the nature of the change and its formative processes. This may be useful for the given region by arguing through analogy. On the other hand, the concern may be oriented to detecting **new changes** as they occur or as they become recognized as significant. Both of these aspects of change detection are important for any agency whose mandate is to carry out a "watch-dog" role in relation to the resource base. The detection of change under these circumstances is not such an outlandish exercise as it might at first appear. We live in an era of rapid change, with many unexpected impacts and it is quite reasonable to assume that this will continue. Evidently, the faster we are able to detect changes, or the unforeseen impacts of change, environmentally or otherwise, the better we will be able to respond to them.

Furthermore, there are two distinct, though often interrelated, objectives of land-use monitoring that should be recognized:

- to monitor the amount, location, and type of land-use change; and
- to understand the relationships that underlie a particular type of land-use change, for example, between changes in technology or the socio-economic structure of agricultural production and agricultural land degradation.

Before discussing the implications of different combinations of monitoring objectives and types of sampling, it is important to note that the design and selection of a sampling strategy based on probability theory is influenced by a number of considerations including:

- the **magnitude** of the change (e.g., proportion of total area affected by the change). A major problem for land-use monitoring through sampling is that many changes are likely to be small in proportion to the total regional area. This can be aggravated by the presence of other error sources, for example, misclassification error;
- the **spatial form** of the change and, indirectly, the underlying **processes**; and
- the **variety** of changes to be monitored.

All of these considerations presuppose some knowledge of the change phenomenon being monitored. This knowledge helps determine, among other things, the appropriate type of stratification, size of cluster or cell to be used as the sampling unit, and the relationship between successive samples over time. Clearly, in the **detection of change**, the knowledge base about a particular process of change may be very limited. This differential knowledge base is a major problem in designing general sampling strategies to detect change.

The four possible combinations of monitoring types and objectives, given the classification outlined above, are identified in Table 2. In only one case, where the objective involves tracking "known" phenomenon and where the focus is on estimating the magnitude and location of change, is a probability sampling approach clearly indicated. The more problem-specific the task (as opposed, for instance, to general purpose land-use monitoring), the easier it is to design a cost-effective probability sampling strategy to provide reliable estimates of the phenomenon, within whatever time frame and spatial re-

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Table 2
Monitoring Types, Monitoring Objectives, and the Relationship to Sampling Approaches

Types of Monitoring / Objectives of Monitoring	Following "Known" Changes	Detecting Change
Quantitative	• "known" distributions • possible to design an effective probability sampling strategy	• difficult to design a probability sampling strategy • the "rescue" problem for "insignificant" uses or changes at time t that become significant later on • role of remote sensing • potential role of "regional observatories" and/or representative areas.
Understanding Relationships	• complexity of relationships and regional variability suggests focus on set of representative areas • potential role of "regional observatories" in relation to these	• prior notion of broad regional structures (though not necessarily linked to "new" change) as a basis for selecting representative areas and/or organizing "regional observatories"

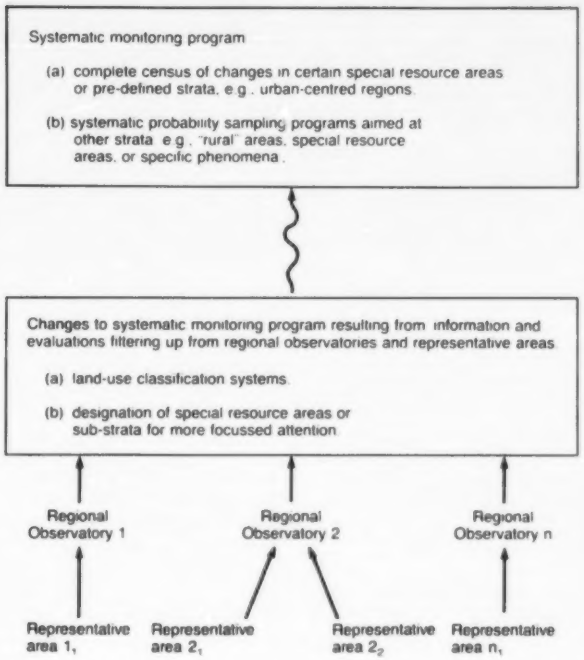
porting unit is required. In other cases, some form of judgmental sampling based on the selection of "representative areas" may be appropriate. Of course, once more information becomes available about a particular phenomenon and greater understanding is achieved, it would be possible to develop specific probability sampling strategies for particular regions, and/or to consider incorporating the monitoring of such phenomena into a more general purpose land-use monitoring program.

The combined notions of **representative areas** and **regional observatories** deserves additional comment. In the case of tracking phenomena about which some knowledge already exists, but where the focus is on understanding relationships, the selection of representative areas across the country would permit a concentration of effort on establishing linkages between land use, change, and other elements of the environment. While the nature of the information obtained would not permit the establishment of estimates of change within given levels of precision, a greater understanding of functional relationships (so vital for informed decision making) and how they might vary from region to region would be attained. Sampling approaches of various types could be utilized within a given representative area, but they would not be part of a monolithic probability strategy and might well involve other more localized forms of judgmental sampling in any case.

For monitoring involving the **detection of new change**, whether with a quantitative focus or with a concern for deepening the understanding of functional relationships, representative areas are again appropriate. Remote sensing certainly offers the potential in the long-term for detecting a wide range of changes. Even here, however, focussing on representative areas initially could prove more effective than a more geographically-comprehensive approach, particularly given the likelihood of strong patterns of regional variation in future land-use changes. The key is to provide an on-going synthesis and filtering of information relating to the representative areas from a wide variety of information sources. It is here that the notion of regional observatories could be extremely useful.

Regional observatories would ensure that new changes/processes were "rescued" and identified as early as possible. They could focus on one or, more likely, several representative areas (*see* Figure 1). Their function would be to serve as a vehicle through which information on land use from many sources could be synthesized to determine what is worth monitoring on a more systematic basis. In this way, adjustments to land-use classification systems and other parts of the more systematic elements of a monitoring program could be recommended.

Figure 1
Regional Observatories and Representative Areas in a Land-Use Monitoring Program


Systematic monitoring program
(a) complete census of changes in certain special resource areas or pre-defined strata, e.g., urban-centred regions
(b) systematic probability sampling programs aimed at other strata e.g., "rural" areas, special resource areas, or specific phenomena
Changes to systematic monitoring program resulting from information and evaluations filtering up from regional observatories and representative areas
(a) land-use classification systems
(b) designation of special resource areas or sub-strata for more focussed attention
Regional Observatory 1
Regional Observatory 2
Regional Observatory n
Representative area 1,
Representative area 2,
Representative area 2,
Representative area n,

How would such an observatory system be organized? The suggestion is to create a base for an observatory within an existing institutional structure. An existing government office or regional professional association could form the base. However, given the need for lack of bias and for a forum in which all viewpoints can be freely exchanged, a university or other post-secondary educational institution would appear to be an obvious candidate. Through networking, a system of contacts could be rapidly developed; these could be utilized to create and develop a source documentation centre and would provide the main resource people to participate in periodic workshops or brain-storming sessions on trends and new developments within the geographic context of the regional observatory. These sessions would provide the main feedback mechanism to the systematic part of the national monitoring program.

CONCLUSIONS

In summary, it has been argued that the very nature of monitoring land-use change means that probability sampling strategies can only address certain concerns of land-use monitoring. Once particular phenomena have been identified and some understanding achieved, it becomes reasonable to consider the development of probability sampling approaches to provide estimates of the progress of the change over time. Even here, general purpose land-use monitoring may not be the appropriate structure to use. For other monitoring concerns, especially those involving change detection, some combination of representative areas and regional observatories is suggested. The latter would provide a systematic means of signalling new changes and of introducing them into a national land-use monitoring program for consideration. It is known, for instance, that long before particular issues become the object of public concern and intervention, some observers have often already identified them. Regional observatories could also provide a seed-bed of new ideas for research themes for researchers, including students, and provide therefore a way of harnessing more effectively our intellectual resources in understanding and, ultimately, in providing solutions to changing resource management problems.

Chris Bryant is from the Faculty of Environmental Studies at the University of Waterloo, Ontario.

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GEOGRAPHIC INFORMATION SYSTEMS: OPTIONS FOR MONITORING

Ian K. Crain

This paper discusses the relationship between Geographic Information Systems (GIS) and land monitoring. It outlines different types of GIS and their advantages, evaluates options for using a GIS for monitoring, and suggests ways of choosing a system.

INTRODUCTION

Geographic Information Systems, or GIS, are defined in *The Canadian Encyclopedia* (1985) as "systems designed to store and manipulate data relating to locations on the Earth's surface." This definition includes a wide range of information systems, from those registering census and geo-coded data, to the simple recording of the province in which an activity took place, through to powerful general-purpose topological systems. In the more focussed context of land monitoring, however, the term is normally used to refer to systems which maintain thematic geographic boundaries, such as Arc/Info[1], CARIS[2], SPANS[3], Canada Land Data System (CLDS)[4], Comarc[5], etc.

GEOGRAPHIC INFORMATION SYSTEM REQUIREMENTS FOR LAND MONITORING

The term Geographic Information System encompasses a very broad range of systems, from a simple electronic planimeter to a comprehensive general purpose computerized system such as CLDS. Most systems however, contain the basic capabilities required by land monitoring. The most common functional requirements of land-use monitoring are as follows:

- **Data capture**: It is necessary to acquire and store spatial information, often in large volumes. The representation of spatial elements, such as an area or a boundary, requires a vast number of x-y coordinate pairs to outline them accurately. This is a step beyond the requirements of ordinary information systems where the data is largely non-spatial. In land-use monitoring there is **always** a geographic component;
- **Retrieval**: Selective retrieval from the data collections for user purposes is required for simplification reasons, as well as for reasons of information "generalization";
- **Derived outputs**: Various kinds of derived outputs from data banks including maps, tabulations, and reports are needed. Some options are described in the section "Benefits of Geographic Information Systems";
- **Quantitative Analysis**: There is a need to complete quantitative analysis of the spatial data, for example, geometric calculations and cross-tabulations;
- **Temporal comparison**: This is the functional requirement which makes monitoring unique from other types of geographic inventory analysis. The purpose of monitoring is to examine phenomena in more than one time frame, and analyze what has changed. The Canada Land Data System is capable of **temporal overlay** and has undergone considerable modification in the past five years to take into account the requirements for temporal comparison. Temporal overlay as a special problem related to monitoring is discussed below;
- **Thematic overlays**: The superimposition of different thematic coverages such as land use, political boundaries, land capability, etc., is necessary for change-monitoring analysis;
- **Geometric manipulations**: There are many kinds of geometric manipulations and geographic retrieval that users may desire. Differences between GIS lie largely in their ability to perform geometric manipulations. For example, simple manipulations may include scale change, while a very complicated manipulation may involve size and shape analysis of various features;

Details on these types of GIS may be obtained from the following:
[1]Arc/Info, ESRI (Environmental Systems Research Institute), Redlands, CA. 92373.
[2]CARIS, Universal Systems, 259 Brunswick St., Fredericton, New Brunswick. E3B 1G8.
[3]SPANS, TYDAC Technologies Inc., 1600 Carling Ave., Ottawa, Ontario. K1Z 8R7.
[4]CLDS, Lands Directorate, Environment Canada, 351 St. Joseph Blvd., Hull, Quebec. K1A 0E7.
[5]Comarc Systems, 150 Executive Park Blvd., San Francisco, CA. 94134-3399.

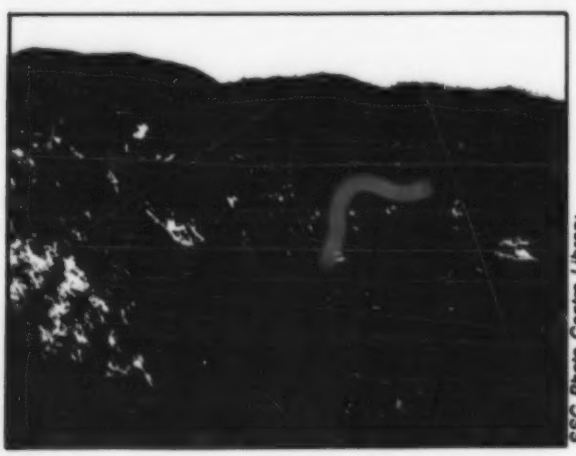
- **Modelling**: Finally, it is desirable to **model** the results to provide answers to the "what if" questions.

OPTIONS FOR MONITORING

There are three basic approaches to land-use monitoring. One approach is referred to as **total re-mapping**. For each temporal period the complete land base is mapped and then the two maps are compared to identify what has changed. A number of problems are associated with this approach. First, it generates high volumes of data, both in the physical sense — a large stack of maps; and in the computer sense — a large quantity of digital data. Second, it creates a problem of **spatial overlay misalignment**, otherwise known as "sliver problems", "slices", or "line weave". This occurs when interpreters attempt to draw the same polygon for two or more periods. Although no land-use change has in fact occurred, it is impossible to draw exactly coincident lines, and thus automated analysis will identify all of these small slivers adjacent to major areas as additional areas of change. Usually, these types of errors are not important when doing an **inventory** because they tend to even out. Small errors in favour of forestry in one part of the map may be offset by small errors in agriculture in another area. In change monitoring, however, it is a **biased error**. There will always be more apparent change than is real. The total re-mapping approach exaggerates this type of problem.

There are ways to offset this misalignment problem with automated means, but it can never be completely eliminated. A bias will always be created in favour of identifying more change than really exists. This problem is not unique to any particular type of GIS. Remote sensing systems have the same problem. For example, pixels may appear to have changed simply because they are very slightly shifted each time the satellite passes over a particular area. Thus, change analysis generates halos of apparent change around areas that have not changed at all.

An alternate approach is **change mapping**. In this case much more of the quality control lies with the interpreter who views both sets of air photos, examining the situation in both periods, and then maps changes from an expert point of view. Although it eliminates many of the difficulties of misalignment, change



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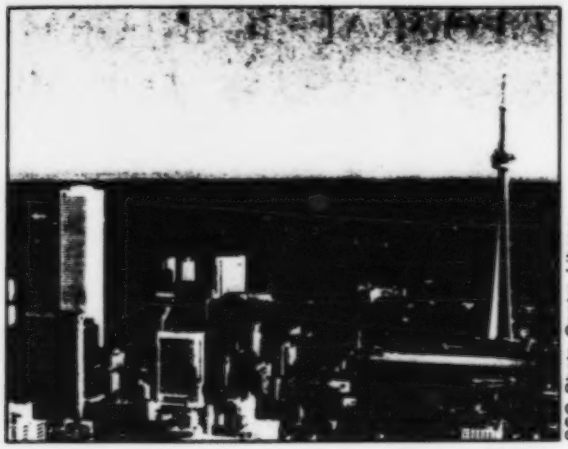
Open pit mine, Faro, Yukon



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mapping also has some problems. The total coverage map for the second period and subsequent periods are **derived products**, rather than direct products. **Reinterpretation** is another problem. Given that temporal interpretations are a number of years apart, the interpreters and their standards may change between interpretation cycles. Thus, there can be a tendency to identify change which is merely a reinterpretation. Again, a bias is created towards identifying more change than really has taken place. The advantages, however, include having less data to handle, putting the interpretation decisions with the interpreter rather than with a computer system, and having fewer misalignment errors.

Another method is called **representative area mapping**. This is independent of the first two options and can be used in conjunction with either approach. Representative area mapping is the process of selecting representative areas, or extensive samples, in which one maps in detail using either the method of total re-mapping or change mapping. These selected areas are used to represent all of Canada or all of the relevant study area. However, this approach requires a good model for extrapolating from the selected areas to the whole being represented. It also has some related sampling error problems. The main advantage is that there is much less data to manipulate. Thus, more effort is concentrated on the analysis of change processes than otherwise could have been afforded if the entire country was mapped.

The Canada Land Use Monitoring Program has used all of the above options in projects requiring GIS support. This experience has demonstrated that the second approach of change mapping is usually the most appropriate for land-use monitoring. Representative area mapping is favoured for more specialized applications where monitoring relates to particular land uses which are well distributed throughout the total study area.

BENEFITS OF GEOGRAPHIC INFORMATION SYSTEMS

The benefits of using a GIS for monitoring include consistency, as well as the ability to have reproducable results independent

of operators. The same answer will be obtained for the same question every time. A second advantage is that the data can be reinterpreted in future; for example, the data may be re-used against different standards and against different models.

In terms of both the volume and complexity of the data which can be handled, the automated system has many benefits. It was estimated in the early days of the Canada Land Inventory that, without a computerized system, a staff of about 500 people would be needed solely to answer relatively simple queries about the land base.

A GIS makes it easier to perform modelling studies for various "what-if" options and scenarios. Finally, there are many advantages in being able to quickly produce the graphic outputs which are so essential in a map-based monitoring program. One of the simplest forms of graphic output that can be obtained from a GIS is the monochrome, simple line plot, usually produced interactively either for quick viewing and analysis, or for quick reports from a model, or as a result of selective retrieval. Slightly more advanced interactive plots use colour to show various themes. Hard copy outputs include simple line plots where the attributes of the areas are identified by code numbers or symbols. These are useful either as a desk reference or as a map to use in field verification. Such maps can be colour-shaded, producing a useful working diagram. Publication quality maps can be produced by a laser plotter such as the Optronics scanner housed in CLDS.

CHOOSING A GEOGRAPHIC INFORMATION SYSTEM

In choosing a GIS the following two steps are appropriate. First, it is necessary to **define your needs** in functional terms and to quantify these needs by looking at "how much" and "how often". Give some consideration to how you want the system to grow, and to what your needs will probably be in five years. Second, start looking at **available GISs and their capabilities**, compare them to your needs, determine what the costs are, and choose the best **performance-cost ratio**.

These steps are non-trivial. Perhaps the dominant and most important part of selecting a GIS is the first one. If you can define your needs, the rest of the selection process will be relatively easy.

Ian Crain is Chief, Canada Land Data System, Lands Directorate, Environment Canada, Ottawa.

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FOREST LAND MONITORING – AN UNHAPPY SCENE

Gordon F. Weetman

To provide public assurance that Canada's forests are well managed, an improved forest inventory, a better knowledge of soil fertility levels and wildlife habitat, and an inventory of recreation and aesthetic values in forest landscapes are all needed. Stable biophysical and dynamic forest-monitoring programs, with data sets and scales useful to local managers, are urgently required. Present monitoring levels are inadequate, but there is a strong mandate for federal/provincial cooperation to establish new, continuous, national monitoring programs and a program of national silviculture auditing.

INTRODUCTION

The maintenance of both landscape quality and a continued supply of goods and services from Canada's forests requires continued assurance that:

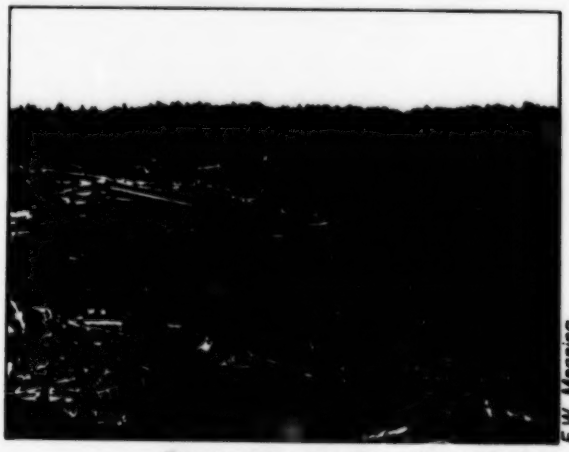
- the present **inventory of commercial timber stocks** is being maintained in terms of age-class distribution within timber supply areas, valuable species composition (particularly on cutover and burned lands), cutting rate regulations, and an acceptable level of loss from fire, insects, and disease;
- the present **fertility levels of forest soils** are not being degraded by land alienation, excessive road construction, careless use of slash burns, excessive nutrient removals from logging, or possible acid rain effects;
- the **wildlife habitat values** are not endangered by careless road construction, logging and silviculture practices along streams, rivers, and lakes, or by excessive liquidation rates of old growth timber in terms of size and timing of clearcuts; and
- the **recreation and aesthetic qualities of forest landscapes** are not upset by logging, road construction, mining, oil and gas exploration and development, or tourism attractions which violate the current set of public values.

There is increasing evidence that "all is not well out there in the woods", not just in terms of local land-use conflicts which are inevitable, but on a very broad scale, in areas far away and not known to most Canadians. The environmental movement of the 1960s and 1970s effectively raised public conciousness regarding pollution, quality of life, and the values of wildlife and landscape. Similarly, the current economic problems in the forest industry have resulted in more public awareness of the apparent sad state of wood supply in Canada's commercial forests.

MONITORING NEEDS

What are the monitoring needs for continued assurance that all is well (or not well) with respect to the forest resource and its land base? First, it is useful to distinguish between those forest land attributes which are stable and those which are not.

Stable attributes are reflected in the physiographic inventory of forest lands. There is no need to reinventory them unless the mapping scale or attribute qualities are not valuable to managers. Unfortunately, this has been a fundamental problem with the original 1:50 000 Canada Land Inventory (CLI), the scale of which is too small for use by forest managers. Furthermore, only land classes, not qualities or characteristics, are mapped, although high priority areas needing finer scale inventory and characterization have been identified. However, to reinventory using useful scales and attributes is an immense national task and nobody is willing to pay for it. A useful inventory of stable landscape characteristics for most of Canada does not exist, although this is undertaken for high use,



E.W. Manning

Forest cutting near Grand Mère, Quebec

conflict, and problem areas (particularly those under federal jurisdiction, for example, national parks). The current practice of "do it as and where needed" often means that land-use decisions are made with very poor knowledge of the landscape.

Should Canada attempt a national biophysiographic inventory of forest lands at a managerially-useful information scale? Perhaps, a federal/provincial agreement could be phased in over a number of years. Without an appropriate inventory, it is very difficult to evaluate the significance of "damage" to stable features of the landscape. In addition, there is real stress on forest land in Canada (Weetman, 1983).

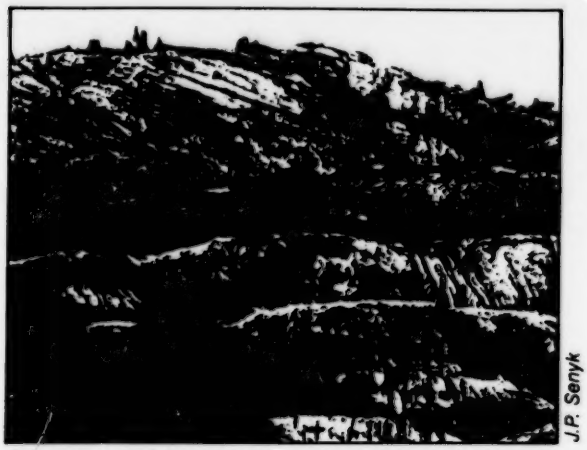
One very positive feature is that Canadian researchers are good at monitoring and inventory. They also know how to do good biophysical surveys. Furthermore, new second-generation satellite imagery at 10 to 30 m spatial resolution is now available. Canada has an international reputation in this field and also exports the technology.

On the negative side, the recent collapse of many federal programs means that it is more difficult to achieve continuity and quality of effort in the field. Federal commitment and continuity of effort are needed. The latest remote sensing technologies and geographical information systems will greatly reduce the task of gathering and processing information regarding the biophysical characteristics of our forest lands. However, this work still requires much coordinated human effort.

Unstable attributes of the forest landscape are those associated with the dynamics of the forest itself, such as the continuous growth of forest age-classes and losses due to fire, insects, and disease. These attributes cannot be inventoried once, but require monitoring. The provinces have learned the hard way that: forest inventories rapidly become out-of-date, thereby becoming misleading; and forest-cover attributes or mapped classifications also become dated.

Finer scales and more detailed information at the forest-stand level are needed. It is possible to store in computer memory vast data sets with 20 or more stand-level attributes, locate them in time and space, and map them to any scale or level of information required (Hegyi, 1985). The technology is very impressive. Much less impressive and alarming is the level of effort that is going into forest inventory and growth and yield studies. For example, British Columbia has completed almost no inventory field work for two years. Field work, permanent sample plots, and cash is needed to **continuously maintain and update a forest inventory**. A **national silviculture audit** program is also required to monitor and guide spending (International Woodworkers of America, 1979; Reed, 1985).

In 1985, Royal Commissions in both Nova Scotia and Ontario recommended that provincial forest inspection systems be established with formal auditing powers for managerial performance. The allegation has been made that there are third world countries with better knowledge of their forests (probably completed with Canadian assistance) than Canada. Although this may not be true, it seems credible. Some of the present provincial and corporate licence forest-inventory sets are archaic, making our allowable cut scenarios inaccurate.



J.P. Senyk

Total removal of the organic veneer, north Vancouver Island, British Columbia.

High technology forest-inventory systems exist in provincial capitals, while regional and district forest-land managers struggle with outdated forest-inventory map sheets, no biophysical data, and vague land-use guidelines.

In the 1960s, there were federal/provincial cost-sharing programs for forest inventory. We are currently back into federal/provincial cost-shared forestry programs on a vast scale. Federal assistance in forest inventory is required; without good inventory, and growth and yield data, there can be no real forest management. There is a legislative mandate for federal involvement in forest inventory on provincial lands under the *Statistics Act* (1971). There are precedents for it and it is in the national interest. The federal government should assist.

The present level of information on, and monitoring of, regeneration and stand development on cutover lands is deplorable. Nationally, we do not know where we are at or where we are going with regard to forest regeneration. Although the technology exists to improve this situation rapidly, outdated systems are maintained.

J.P. Senyk

Forest clearcuts and subsequent slumping north Vancouver Island, British Columbia.

CONCLUSION

The current monitoring of stable and unstable attributes of Canada's forest lands is inadequate to provide assurance to the public, who own the forest, that "all is alright out there". It could be greatly improved. Cooperation is needed between federal and provincial levels of government to establish a national biophysical and attribute monitoring program and modern, continuous, forest-inventory programs.

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Response from the audience:

Terence McRae: You have given us an indication of how you think government should respond to forestry concerns. Could you also tell us how you think private industry should respond?

Gordon Weetman: Most of Canada's commercial forest lands are leased to large corporations using long-term leases under area-based licences. The corporations are usually forced to abide by some provincial forest-inventory system. In many cases, the inventory work they do is paid for by the province. Their incentive to develop a sophisticated system must be tied to the interests of the province in this area since there is total provincial control. However, it is reasonable to expect the major licensees to develop sophisticated monitoring systems on their licensee areas, that is, systems which serve logging, protection, renewal, and environmental needs. Generally, they have not done so. The payments and incentives for monitoring have not been clearly established.

It should be noted that established provincial systems are often driven by political pressures over allowable cut calculations, assignment of logging rights, and so forth. How do we fit all this together? There must be some national level of coordination in this area because the type of information collected at the provincial level often tends not to reflect the national interest. I will not try to suggest mechanisms to achieve federal/provincial cooperation on forest inventory — this requires the wisdom of Solomon.

Bob Ryerson: Your comments are well taken. One of the difficulties encountered in the field of remote sensing is the reticence of people to get involved in and use a new technology. This may be one of the major reasons why few new technologies are being rapidly implemented, particularly at management levels.

TECHNIQUES TO PREDICT THE IMPACT OF LAND DEGRADATION ON FOOD PRODUCTION[1]

Michael Brklacich[2], Ray McBride, and Barry Smit

This paper develops a system for evaluating food production opportunities in a changing environment. It is applied to assessing the implications of 25 years of soil erosion on food production prospects in the agricultural heartland of Ontario. The system is based upon land units characterized by relatively homogeneous areas with respect to current productivities for crops, susceptibility to environmental change, and effects of environmental change on productivity. A mathematical programming model is employed to integrate data on land availability, crop yields, and requirements for food production, and thereby to measure the long-term opportunities for food production.

The system is sufficiently flexible that food production opportunities could be evaluated relative to other environmental changes including climatic change, acid rain, and salinization. There is also opportunity for its implementation in other jurisdictions.

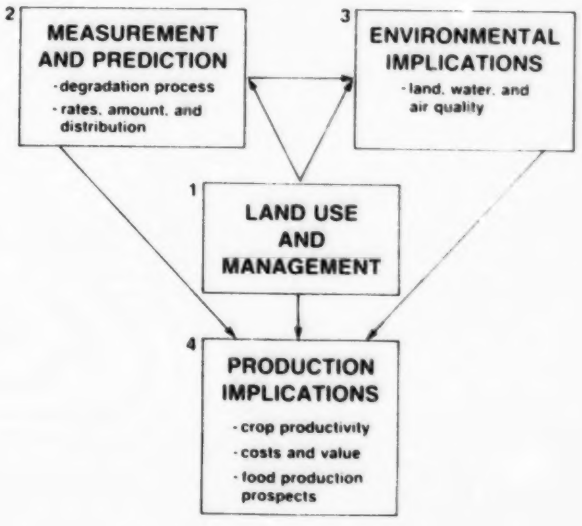
OVERVIEW OF LAND-DEGRADATION RESEARCH

The rationale for land-degradation research is the belief that degradation will hamper long-term opportunities for the production of food and fibre. Agriculture is currently a major contributor to the Canadian economy and current evidence suggests that reductions in the productive capacity of the nation's agricultural land resources could trigger a loss in the security of food supplies, increase the national debt, and threaten the viability of agriculture in Canada (Bentley and Leskiw, 1985; Standing Senate Committee on Agriculture, Fisheries and Forestry, 1984; Coote, 1983).

Despite these concerns, land-degradation research has rarely addressed explicitly the implications of degradation on food production prospects. It has, however, been characterized by thorough examinations of particular aspects of this broader issue and three basic fields of investigation can be identified: degradation measurement and prediction, environmental implications, and production implications. Boxes 1 to 4 of Figure 1 illustrate these interrelationships.

Much of the land-degradation research has concentrated on examining degradation processes such as erosion by water (Morgan, *et al.*, 1984) or wind (Bondy, *et al.*, 1980; Cole, *et al.*, 1983; Lyles, 1983; Slevinsky, 1984), salinization (Campbell and Biederbeck, 1980; Henry and Ballantyne, 1980), acidification (Krug and Frink, 1983; Wiklander, 1973), compaction (Gupta and Larson, 1982; Raghavan, *et al.*, 1982), and on measuring and predicting the rate, amount, and distribution of each form of degradation (Boxes 1 and 2). Traditionally, these analyses have been conducted at the experimental plot or field

Figure 1
Land-Degradation Research



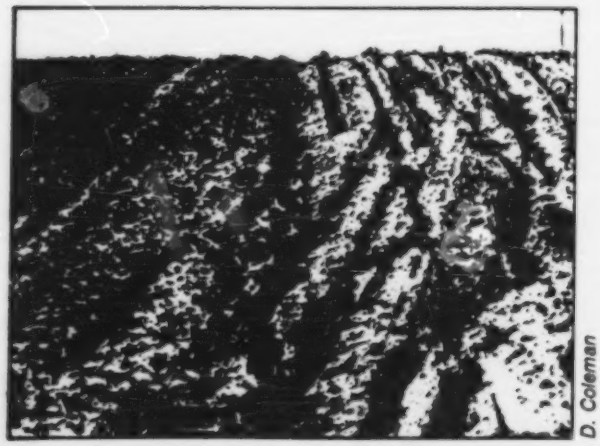
[1]The authors gratefully acknowledge support from the Land Resource Research Institute, Research Branch, Agriculture Canada, the contributions from other members of the Land Evaluation Group, and the Ontario Institute of Pedology.

[2]Michael Brklacich presented the paper at the Workshop.

level, and degradation is measured as a function of the biophysical characteristics of the resource base and the extent to which land-use and management practices either ameliorate or exacerbate the process. More recently, resource analysts have begun to assess the potential for degradation at a broader scale. These assessments have been based upon either a synthesis of the findings from several micro-scale studies (e.g., *see* Standing Senate Committee on Agriculture, Fisheries and Forestry, 1984; Dregne, 1982; Bentley, 1981) or the modification of micro-scale procedures for application at the regional scale (e.g., *see* Shelton, *et al.*, 1984; Coote, *et al.*, 1981). This research has been instrumental in gauging the susceptibility of particular lands to degradation, and has provided a basis for recommending remedial measures to curb degradation. While these findings could provide useful input into assessments of the implications of degradation on food production, they do not directly appraise the consequences of degradation for food production prospects.

The environmental implications associated with land degradation represent another major field of investigation (Box 3). It is linked explicitly to land use and to research investigating the process of degradation (Boxes 1 and 2), and measures the extent to which degradation affects the biophysical characteristics of the resource base. The research is usually conducted at the micro level, but there is now sufficient evidence to indicate the environmental implications of degradation for many regions in Canada (e.g., *see* Bentley and Leskiw, 1985; Anderson and Knapik, 1984; Coote, 1983; Prairie Farm Rehabilitation Administration, 1983). This research has contributed greatly to the understanding of both the on-site and off-site implications of land degradation and indicates clearly that degradation is a societal concern. By themselves, however, these studies provide little insight into the effects of degradation on the long-term adequacy of the resource base for food production.

Assessing the implications of degradation for food production (Box 4) is the newest field of research within the land degradation paradigm, and it complements and extends the other fields of degradation research (Boxes 2 and 3). The effects of past degradation on the current productivity of particular sites for individual crops has been the focus of much of this research



D. Coleman

Gully erosion, Cochrane Clay Belt, Ontario

D. Coleman

Grassed waterway, Middlesex County, Ontario

(e.g., *see* Battiston and Miller, 1984; Langdale and Shrader, 1981; Lyles, 1977). More recently, several researchers have been attempting to model the relationship between degradation and crop yields (e.g., *see* Shaffer, 1985; Williams, *et al.*, 1984; Pierce, *et al.*, 1983; Land Evaluation Group, 1983a). Economic assessments have investigated the impacts of degradation on production costs (e.g., *see* Stonehouse, 1983; and Govindasamy, 1984) and on the total value of agricultural production (e.g., *see* Anderson and Knapik, 1984; Driver and Wall, 1982). In total, these studies have provided a first approximation of the impacts of past degradation on land productivity and on current levels of agricultural production.

But what of the future? It is expected that the demand for North American agricultural commodities, especially grains and oilseeds, will increase substantially (Heady, 1982; Agriculture Canada, 1981). Furthermore, much of this increase in production will need to be obtained by increasing the productivity of existing agricultural lands (Bentley, 1981). If soil conservation is not practised and land-use practices become more intensive, the North American agri-food sector would run the risk of exporting its land resources along with its food products. Clearly, there is a need to support agri-food growth policies with appropriate strategies for sustaining the quality of the land resource (Dyer, 1982).

ROLE OF LAND-DEGRADATION AND LAND-USE MONITORING RESEARCH

Land-degradation and land-use monitoring research can make valuable contributions to strategies in support of agri-food growth initiatives. These fields of research should be providing vital information on the susceptibility of different types of land to degrade under alternative management schemes, on the impacts of degradation on productivity, and on the prospects for attaining future requirements for food production if land conservation measures are, or are not, practised. Without such information, it is difficult for decision makers to identify appropriate types and levels of policy. For example, the unconstrained pursuit of lucrative export markets could promote further intensification of agricultural land use and eventual losses in productive opportunities. On the other hand, unnecessary restrictions on agricultural land use may

result in an underutilization of land resources, and thereby, needlessly increase production costs and restrict food production opportunities. The major objectives of land-degradation and land-use monitoring research should include measuring the prospects for sustainable agricultural production before substantial growth in the agri-food sector is encouraged, and determining the impacts of environmental deterioration on food production opportunities.

PROCEDURES FOR ASSESSING THE IMPACTS OF DEGRADATION ON FOOD PRODUCTION

A system for assessing the long-term impacts of degradation on food production prospects could be developed around the six-step procedure described below. Each of the steps provides input into subsequent steps and hence the procedure represents a systematic approach to evaluating the impacts of degradation on production opportunities. The procedure is sufficiently flexible that it could be applied to any form of degradation, and it can consider possible changes in other biophysical or socio-economic conditions.

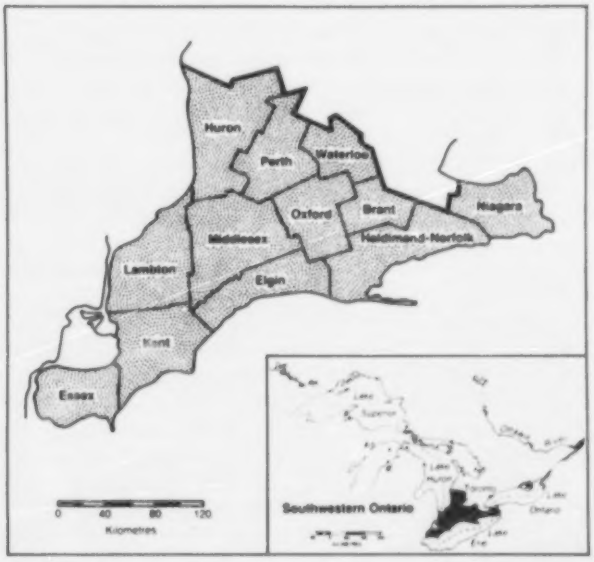
The first step involves **defining land units** that are relatively homogeneous with respect to current productivities for major agricultural uses, susceptibility to degradation, and effects of degradation on land productivity. This information forms the base of Step 2 which includes **estimates of current conditions** including availability for agriculture of each land unit, productivity of these lands for major crops, land-use patterns, and production levels. The third step estimates the **long-term potential for degradation** . These analyses could be conducted assuming that current conditions prevail throughout the designated time period, or relative to possible changes in patterns and practices of land-use management. Step 4 estimates the **impact of degradation on productivity** by examining the yield response for each of the major crops, given the amount of degradation estimated in Step 3. Regardless of the techniques used in this step, it is imperative that these analyses be conducted for each use on each of the identified land units. Step 5 considers **other changes** including possible adjustments in biophysical and socio-economic conditions such as availability of land for agriculture, climatic conditions, and food production levels. Step 6 integrates the data compiled under Steps 2 through 5 and thereby measures **food production potential** under current conditions and the effects of degradation on these production opportunities. Mathematical programming techniques are well-suited for evaluating the long-term adequacy of the resource base for food production under a wide range of scenarios (Brklacich, *et al.*, 1984).

The procedures outlined in this section could be used by resource analysts to address a wide range of issues relating to environmental degradation and conservation. The units of analysis are defined on a consistent basis thereby facilitating assessments over large geographic regions. For example, the procedures would indicate the susceptibility of particular land units to alternative forms of degradation (Step 3) and the effects of degradation on productivity levels (Step 4). By integrating data on resource availability, crop yield response to degradation, and food production targets, the procedures can provide insight into the broader issue of degradation and its impact on the productive capacity of a larger region.

IMPLEMENTING THE PROCEDURE: THE SOUTHWESTERN ONTARIO EXAMPLE

The procedures outlined in the previous section are used to estimate the effects of soil erosion on the opportunities for food production in the southwestern Ontario region (*see* Figure 2). This region was selected because there is considerable information on the current availability, productivity, and use of land in the region (e.g., *see* Land Evaluation Group, 1983b), and there are several studies investigating the erodibility of land in this region under alternative management schemes (e.g., *see* Shelton, *et al.*, 1984), and the relationship between erosion and crop yields (Battiston and Miller, 1984; Land Evaluation Group, 1983a). By selecting southwestern Ontario, it is possible to assess the feasibility of employing existing data to implement the proposed procedure. An outline of the application of this procedure to the southwestern Ontario region and selected findings follow.

Figure 2
Counties of Southwestern Ontario

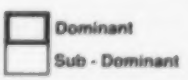


Land Units

Data required to delineate homogeneous land units with respect to current productivity, erosion susceptibility, and crop yield response to erosion have not been compiled on a consistent basis for large geographic regions. It is feasible, however, to derive these data by classifying the land resources in the southwestern Ontario region according to three elements: climate, soil quality, and slope (*see* Table 1).

Table 1
Land-Unit Classification

ELEMENT	CLIMATE	SOIL QUALITY	SLOPE
DATA ITEM	Corn Heat Units Rainfall Rainfall Intensity	Capability Surface Texture Parent Material Texture	Slope Length Slope Steepness
SPATIAL UNIT	Generalized Soil Landscape Map Polygon (GSLM)	Soil-Landscape Relation (SLR) in a GSLM	Slope Category (SC) in a SLR



The **climate** element includes data on corn heat units (CHU), total rainfall, and rainfall intensity. The first two data items are used in estimating current levels of productivity, whereas the last item is used in estimating the long-term potential for soil erosion. Throughout the southwestern Ontario region there is little variation in each of these items, and therefore, these data can be compiled on broadly defined spatial units. Polygons delineated on the Generalized Soil Landscape Map (GSLM) for southern Ontario (scale 1:500 000) represent a suitable spatial unit for these data. Furthermore, it is feasible to develop links amongst these polygons and other information sources relating land quality and use. Data on corn heat units and total rainfall are derived from research conducted by the Land Evaluation Group (LEG) (1983b), and rainfall intensity indices are compiled for these polygons by the Ontario Institute of Pedology (OIP) (Shelton, *et al.*, 1984).

The **soil quality** is based upon three characteristics of the land base: soil capability for crop production, surface texture, and parent material (*see* Table 1). Soil capability is used in estimating current productivity, surface texture represents one of the factors affecting erosion potential, and the texture of the surface and parent material are employed to estimate yield response to erosion. A comparison of the soil and climatic data items for the southwestern Ontario region indicates that the soil data vary more rapidly and to a greater extent than climatic data. This variability in soil quality data required the polygons delineated on the GSLM into soil-landscape relations (SLRs) to be disaggregated. "Dominant" SLRs represent 60% to 85% of polygons, whereas the "subdominant" SLR accounts for more than 15% but less than 40% of the polygon. These SLRs are not necessarily contiguous spatial units, and therefore, they are not delineated on the GSLM (Acton and Harkes, 1984). Data on each of the soil-quality data items are compiled by the OIP (1984).

The **slope** element includes slope length and slope steepness, and these data are employed in estimating the potential for soil erosion (*see* Table 1). Within a particular landscape, slope length and steepness can vary considerably, and hence, the spatial units for which these data are collected are based upon a refinement of the SLR. In the absence of reliable information on the variation and distribution of slopes within a particular landscape throughout the southwestern Ontario region, the LEG (1985) compiled a first approximation of the required data.

Current Conditions

Estimates on the current **availability** of each land unit for agriculture and land-use patterns are derived from OIP data (1984). The OIP provided data on the current (1981) use of each polygon for particular crops. Given the limited opportunity to physically expand the agricultural land base in the southwestern Ontario region (LEG, 1983b), total improved farmland represents a reasonable estimate of the current availability of land for crop production in each polygon. This land availability estimate is disaggregated assuming that the dominant SLR accounts for 60% of each polygon. Further disaggregation into slope categories is based upon the LEG's preliminary assessment of the distribution of particular slopes within a landscape.

Estimates of the **productivity** of each land unit for major crops in southwestern Ontario are derived from research conducted by the LEG (1983b) and based upon climatic conditions (CHUs and total rainfall), soil quality (soil capability), and current levels of management and technology. Current levels of production for each of the major crops in southwestern Ontario are compiled from readily available sources (Ontario Ministry of Agriculture and Food, 1981).

Erosion Potential

A modified version of the Universal Soil Loss Equation (USLE) is used to estimate the long-term potential for **soil erosion** on each land unit. For this particular study, the analysis considers the biophysical conditions which affect the rate of erosion (i.e., rainfall intensity, erodibility of the soil surface, and slope length and steepness) and the extent to which current patterns of agricultural land use would exacerbate or ameliorate this potential over a 25-year period. It would be a relatively simple exercise to extend the study and assess the long-term potential for soil erosion given alternative land-use patterns and management practices such as conservation management, strip cropping or more intensive continuous row cropping.

Long-term soil erosion estimates for each land unit are summarized in Table 2. The findings indicate that the amount of soil erosion would vary considerably across the region, and that for most land units the soil erosion would not exceed the rate of soil formation or 2.5 cm per 25 years. Soil erosion rates of more than 2.5 cm per 25-year period would be anticipated over a relatively small portion of the region. These findings appear to be consistent with other studies which indicate that in most areas erosion proceeds at an imperceptable rate, and that the severe examples of soil erosion tend to be restricted to a few areas.

These coefficients consider the long-term estimate of erosion on each land unit, and the suitability of the surface zone of the soil for crop growth relative to the lower soil zones. Soil texture is used as the primary indicator of suitability. Yield responses to soil erosion used in this study reflect possible changes in yields between the present (1976-1981) and 25 years into the future, rather than yield response rates that would characterize the difference between yields on a newly broken soil and yields after a long period of intensive agriculture.

Estimates of the impacts of 25 years of soil erosion on each land unit on row crop yields are summarized in Table 3. These preliminary findings appear to be consistent with other studies which indicate that severe declines in crop yields would probably be confined to a relatively small portion of the landscape.

Soil erosion-productivity research will continue to contribute to the understanding of the sensitivity of yields for particular crops to different rates of erosion. Assessments of the impacts of erosion on production costs would certainly require these data, and this information would also provide some insight into the extent to which erosion might affect the long-term adequacy of the resource base for food production. Investigations into the implications of erosion for food production prospects, however, would need to consider a broader range of factors, especially the requirements for food production, and be conducted for broad regions rather than individual land units.

Table 2
Long-Term Soil Erosion Estimates for Southwestern Ontario[1]

	Soil Erosion Rate (cm)			
	< 2.5	2.5 to 4.9	5.0 to 7.4	> 7.5
No. of Land Units	459	85	49	20
Land Area (000's ha)	1 109	338	169	59
% of Available Land	66	20	10	4

[1] 25-Year Erosion Estimate

This analysis could be used to indicate the susceptibility of different lands to erosion and extended to evaluate the effects of alternative management practices on potential erosion. While this information could be used as a basis for recommending where remedial measures for soil erosion are needed, it does not in itself appraise the consequences of erosion for food production prospects. The latter analysis would need to consider the impacts of erosion on crop yields and food production levels, as well as on long-term estimates for soil erosion.

Crop Yield Response To Erosion

The measurement and prediction of the **response of crop yields** to erosion is an area of continuing research, and a model with the capacity to develop reliable yield response coefficients for the southwestern Ontario region is not yet available. For this study, crop yield response coefficients to different rates of erosion are based upon a synthesis of independent research into the impacts of erosion on productivity.

Table 3
Effect of Erosion on Row Crop Yields[1]

	Yield Response of Row Crops to Erosion (%)		
	< −2.5	−2.5 to −4.9	> −5.0
No. of Land Units	590	13	10
Land Area (000's ha)	1 603	48	21
% of Available Land	96	3	1

[1] 25-Year Erosion Estimate

Erosion And Production Potential

The final step in this study assesses the **impact of soil erosion on food production** prospects. The long-term prospects for food production under particular sets of environmental and socio-economic conditions are measured through a mathematical programming model. The model is run under two sets

of conditions and the findings are compared. Scenario 1 represents the continuance of current conditions in the region. In Scenario 2, yields are adjusted to reflect the impacts of 25 years of soil erosion on crop yields. Hence, the study isolates the effects of erosion on production potential. The model could, however, gauge the combined impacts of erosion and changes in other conditions, such as land availability on food production prospects.

The estimated effect of 25 years of soil erosion on the potential for food production in southwestern Ontario are summarized in Table 4. Under Scenario 1, production estimates for all crops in the region are 3.8% greater than current levels of production.

generally environmental degradation, on the long-term adequacy of the land resource base for food production. Historically, degradation research has concentrated on various aspects of the process and on the extent to which these changes might alter other environmental parameters. Aggregations of these microstudies have been hampered by the application of several non-compatible techniques for assessing degradation, and by inadequate procedures for tracing the impacts of degradation through the biophysical and socio-economic environment. This study illustrates that it is feasible to integrate these independent research efforts and thereby explore the overall impacts of degradation on the long-term opportunities for food production.

Table 4
Effect of Soil Erosion on Production Prospects[1]

Crop	Current Production	Production Prospects (Tonnes)		Lost Opportunities	
		Scenario 1 Current Conditions	Scenario 2 After Erosion	Tonnes	$ 000's
Barley	379 800	394 267	393 928	338	34
Fodder Corn	3 491 340	3 624 325	3 621 217	3 107	60
Grain Corn	3 541 060	3 675 939	3 672 787	3 152	344
Hay	1 681 980	1 746 047	1 744 550	1 497	78
Oats	218 560	226 885	226 690	195	22
Soybeans	659 380	684 496	683 909	587	141
White Beans	63 280	65 690	65 634	56	15
Winter Wheat	511 940	531 440	530 984	456	54
Total					748

[1] Based on 1981 market prices for major crops in Ontario (Ontario Ministry of Agriculture and Food, 1981).

Given the previously estimated rates of soil erosion and associated reductions in row crop yields, only minor reductions in the production prospects for the southwestern Ontario region would be expected. From an economic perspective, this represents a potential loss in the total value of crop production of about $748 000.

DISCUSSION AND CONCLUSION

The research indicates that it is feasible to assess systematically the broadscale implications of soil erosion, and more

SSC Photo Centre Library

Horticultural crops, National Capital Region

The application of the procedures outlined in this paper to the issue of soil erosion and its implications for food production in southwestern Ontario has been constrained by the quality of existing data sources. Estimates of the long-term potential for soil erosion and its effects on crop yields used in this study represent first approximations of the necessary data. A prerequisite for the use of these techniques as an integral part of the policy formulation process should be the compilation of reliable estimates of degradation and its impacts on productivity. In their absence, the collective ability to measure the long-term prospects for sustainable food production and to evaluate food production opportunities in a changing environment will continue to be limited. Clearly, major contributions of land-degradation and land-use monitoring research should include the refinement of a framework for assessing the impacts of degradation on food production potential, and guidelines for the efficient compilation of required data.

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Response from the audience:

Neil Seely: In yesterday's workshop session, our group decided that a biophysical classification inventory in Canada would be extremely useful. Would this have been useful in your particular study and would it be useful for future studies?

Michael Brklacich: Yes. The ability to implement these procedures rests largely upon the availability of particular types of information. Important criteria can be extracted from an inventory of the biophysical environment. Our needs are for some very particular aspects from such an inventory.

Neil Seely: In some parts of the country it has been said that soil has merely become the medium to hold plants up and that all the nutrients required to grow the plant must be added. We must have a method to monitor degradation and it is not simple. It is a very complex issue. I do not know how to monitor it accurately. Perhaps it is possible to use remote sensing techniques to monitor, for example, something as widespread as salinity in western Canada. But, how can soil erosion problems be monitored unless some of the biophysical information is linked together?

Michael Brklacich: The chief reason for using the techniques outlined in the paper was to address the "what if" questions. In many instances, there seems to be a suspicion that a good inventory of the biophysical characteristics and the relationships between different forms of degradation will indicate the extent to which food production opportunities will be affected by degradation. I think that biophysical characteristics provide some insight into degradation risk, but they do not assess this issue directly. At Guelph, we are trying to develop a series of links between the biophysical information and crude indicators of socio-economic conditions, that is, food production targets.

Gerry Luciuk: I have two questions. The first one is general and arises from your introduction. The second one relates to what you are attempting to accomplish in this study. First, you implied that intensification of land use or cropping systems is automatically linked to a stress on the land. I do not believe that that is necessarily the case. In fact, the reverse may be true. Would you please clarify?

Second, with respect to your particular study, there are either some data shortcomings or some irreconcilable differences between what your findings suggest and what some other larger scale studies indicate. These studies show that $60 to $70 million may be attributable to erosion, particularly in Ontario. What are the data problems or is one set of analyses taking us in the wrong direction?

Michael Brklacich: The first question is very easy to respond to. My comments on intensification relate to southern Ontario where intensification is thought to lead to further degradation. In western Canada, where efforts are being made to reduce the amount of fallow land, intensification could be a way to encourage soil conservation.

Addressing your second question, let me comment on our findings in comparison with those from elsewhere. An extensively used study, conducted by the Ontario Institute of Pedology (OIP), estimates that soil erosion is currently costing southern Ontario farming approximately $70 million. This is considerably more than the amounts discussed here. The OIP assessment is conducted relative to the amount of erosion that has occurred in the last 50 to 75 years of agriculture and indicates that past erosion depresses current levels of production. There is a large difference in the aim of the OIP study and the study presented today. Our study assesses the impact of an additional 25 years of erosion relative to current levels of production.

In addition, I would like to address the issue of data requirements. Our ability to develop the bridge between degradation and yield response is very limited. It is an area of ongoing research and given the available information, we simply could not model how yields are expected to change. What we did represents a first approximation. We had measures of the suitability of the soil as a medium for crop development based on the texture of the surface and parent material. Gross generalizations were made and clearly improvements can be achieved.

— WORKSHOPS —

METHODS AND TECHNIQUES FOR LAND-USE CHANGE AND DEGRADATION MONITORING

A. Methods and Techniques to Monitor Land Degradation.

B. Remote Sensing: Application to Land-Use and Land-Quality Monitoring.

C. The Role of Automated Information Systems in Monitoring.

D. The Potential of Existing Data Sets for Monitoring.

E. Standards for Monitoring Change at Regional, Provincial, and National Levels.

F. Should Land-Use and Land-Degradation Monitoring Programs be Integrated?

A. METHODS AND TECHNIQUES TO MONITOR LAND DEGRADATION

Chair: Lorne Russwurm
Rapporteur: Dell Coleman

Alan Aldred
Ken Beanlands
Gerry Luciuk
Bruce MacLean
Fernand Martin
Jack Millar
Dennis Walsh

QUESTIONS ADDRESSED

- What methods and techniques are appropriate to monitor specific forms of degradation (e.g., air photography, satellite imagery, crop soil loss reports, ground surveys)? How effective are they? What other methods and techniques might be employed?
- What types and scale of land degradation are most amenable to monitoring by specific techniques?

WORKSHOP DISCUSSION

A definition of land degradation is required before any discussion on monitoring methods and techniques. **Land degradation** may apply to a change from natural cover, or to a human modification of a natural, ongoing process. However, both of these aspects relate to a decline or change from an initial base level.

There is a perceptual component to land degradation. For example, in Scotland, the people appreciate the view of their rocky hillsides. To attempt reforestation would degrade the view. With this in mind, it is pertinent to ask when is change considered to be degradation and not simply a change? No definitive resolution to this question was achieved by the workshop group. The answer, however, depends on the desired use of the land, in itself a perception likely to vary between parties. Another discussion point suggested that in some cases land allocation may be considered degradation, with land alienation being the ultimate form of degradation.

Prairie Farm Rehabilitation Administration

Soil salinity southwest of Vegreville, Alberta

In land degradation, there is a need to look at **physical practices** and **management techniques** to maintain enhance the quality of the physical resource. It was recognized, however, that it is difficult to assign a dollar value to alternative land uses because of the limitations of cost-benefit analysis on environmental values. The most desirable use from an environmental standpoint may not be the most cost-effective use for that land.

Forestry and agriculture require different monitoring systems because forestry cycles are much longer. In forest monitoring, **remote sensing** and **air photo interpretation** methods have proven to be quite successful. The wider availability of **geographic information systems** (GIS) allows more inputting, manipulation, and analysis of data. GIS are also beneficial for updating and examining the temporal aspects of change. The group generally agreed that the older survey techniques were too slow to give managers timely information. With good baseline information, it would be possible to compare forest productivity and depletions from the forest stock and, thereby, evaluate the application of various management strategies.

The use of satellite imagery in degradation studies is increasing. However, the scope of the degradation change with time can mean that satellite imagery is inadequate. In a recent study on prairie wetlands, for example, colour infrared photography was used because change to the small and dispersed nature of the habitat did not show up adequately in the temporal sequencing.

In addition to monitoring change with respect to existing problems, there is also a need to identify developing problems. Recognizing that there is and will continue to be insufficient funding for land degradation research, the use of administrative statistics could be useful where little else is available. For example, trends in fertilizer sales and crop yields could be used as **socio-economic indicators** of land degradation.

Generally, the group agreed that the lack of knowledge of land degradation hinders informed decisions on its monitoring.

Various levels of detail and scale are required for different types of monitoring problems. For example, regional overviews are generally completed at a scale of approximately 1:250 000, soil mapping is compiled at 1:50 000, and detailed site work is undertaken at a scale of about 1:20 000. In Quebec, however, zones of dredging along lakes and rivers are being mapped at a scale of 1:2 000 for the preparation of flood-risk maps.

In the forestry sector, a wide range of scales is also needed. For example, in acid rain research it is appropriate to study individual trees in order to analyze the effects of acid rain on tree growth. On the other hand, aerial photography may be used to collect information on genetic depletion due to selective cutting. Moreover, an acid rain impact study of the whole of eastern Canada would require information at a macro scale.

SUMMARY

Land degradation may be the result of natural physical processes, a designated allocation of land use, land-management decisions, or a combination of these. The perception of the degree of degradation, however, will differ between individuals and sectors.

Different sectors, and programs within one sector, require different methods to monitor land degradation. These methods and techniques must be flexible with respect to the types and scales of information that can be accommodated.

B. REMOTE SENSING: APPLICATION TO LAND-USE AND LAND-QUALITY MONITORING

Chair: Richard Mussakowski
Rapporteur: Harold Moore

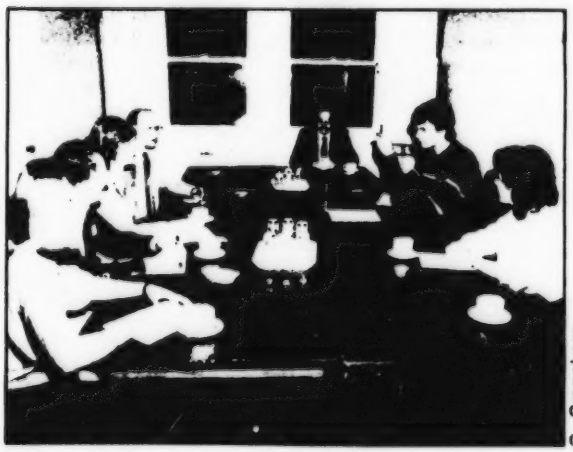
Bob Huang
Michel Melançon
Réal Michaud
Roberge Michaud
Lawrence Peters
Bob Ryerson
David Wilson

QUESTIONS ADDRESSED

- What is the existing state-of-the-art in remote sensing in terms of applicability to land-use and land-quality monitoring (e.g., satellite imagery, multispectral scanners, side-scanning radar)?
- What are the limitations of remote sensing in land-use and land-quality monitoring (e.g., cost, quality, timeliness)?
- Can satellite imagery be used in conjunction with conventional data sources (e.g., air photos) to provide a more cost-effective response to land-use and land-quality monitoring requirements?
- What new technology is available or may be available soon which should be evaluated for land-use and land-quality monitoring?
- What are the pros and cons of digital analysis vs. visual interpretation for land-use and quality parameters especially for time-series analysis?

WORKSHOP DISCUSSION

The state-of-the-art in remote sensing ranges from meteorological satellite to airborne photography. The following types of remote sensing systems were discussed and evaluated in terms of their applicability to land-use and land-quality monitoring:



G. Greenberg

Workshop discussion

- **Meteorological satellite** data of small scale, broad coverage, and high repeatability, can be used to monitor the state of vegetation and agricultural crops over large areas to measure, for example, the extent of drought. This type of data is, for example, available from the National Oceanic and Atmospheric Administration (NOAA) and the Geostationary Operational Environmental Satellite (GOES).
- **LANDSAT Multispectral Scanner (MSS)** data has been shown to be useful for overview monitoring of soil salinity, rangeland management, forest harvesting, fires, agricultural expansion into forest land, and urban expansion into agricultural areas. The resolution may not allow the interpretation of all the required detail. These data are best used for reconnaissance and surveillance to detect changes quickly.
- **LANDSAT Thematic Mapper (TM)** data has great potential for mapping and monitoring land changes. The increased spectral range relative to MSS should provide more land-cover information with higher accuracy. The high volumes of data in each TM scene make operational digital analysis a difficult task. However, the higher spatial resolution makes visual interpretation more reliable and faster.
- **Airborne scanners** are still primarily in the research and development stage and at present have few operational applications. The scanners are most useful for measuring and mapping features requiring quantification, for example, areas of a single crop such as canola. Such scanners will become more operational in the near- to mid-future. They often must compete with established photographic methods.
- **Air photography** has been, and will continue to be, one of the prime monitoring tools for land-use and land-quality assessment. There is a demonstrated cost and time saving when using colour or colour infrared (IR) data compared to black and white. In the

future, smaller scale and/or format colour photography should be used for monitoring.

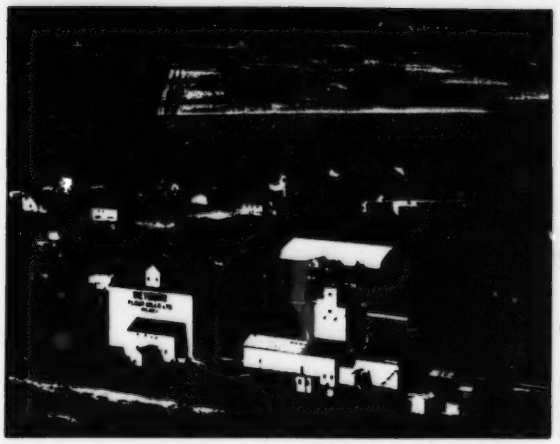
- **Airborne video remote sensing** is a relatively new tool which shows considerable potential for monitoring land use and, to a lesser extent, land quality. The rapidly changing video technology, for example, colour IR video, will lead to many new applications.
- More exotic sensing systems, such as **thermogeography** and **radar,** have relatively few land-use applications at this time. This may be partly due to poor understanding of the potential application of data from these systems.

Future technologies that should be evaluated for their usefulness in land-use and land-quality monitoring are new satellites such as **SPOT** (le Système Probatoire d'Observation de la Terre) and **RADARSAT** (a Canadian radar satellite scheduled for launching in 1990). The potential should be explored, but with caution because these new data sets may add confusion to monitoring procedures.

The spectral information received from SPOT is not as good as that from TM. The bands are wider and fewer in number. SPOT has a better spatial resolution, but perhaps not enough to facilitate urban land-use mapping. For other types of land-use mapping programs, TM seems quite satisfactory. Therefore, the 10-20 m resolution gained with SPOT may not be particularly valuable. However, it definitely will improve visual analysis of the data due to its dependence on spatial resolution.

The fast expanding **micro-computer technology** shows great potential for allowing many more users to complete land-use and land-quality mapping and monitoring. These systems are quickly developing into efficient **geographic information systems** (GIS) and **image analysis systems**. Their efficiency is achieved from the integration of remote sensing data with other sources of information, for example, soil capability maps. By using an expert interpreter as an integral part of the system, the efficiency of data handling and interpretation is maximized.

When comparing **digital analysis** and **visual interpretation**, it is important that the meanings of these terms are clear. While analysis and interpretation can work together, their differences should be stressed. Digital analysis can be very efficient if the land-use parameters are easily detected and must be quantified for the monitoring of change, for example, area of potatoes or silt load of water bodies. However, many land-use or land-quality parameters are very complex and inter-related. In order to use remote sensing to monitor these parameters, the data must be integrated with other information and interpreted by trained personnel with good understanding of land-use processes.



SSC Photo Centre Library

Weyburn, Saskatchewan

In the future, it is expected that the high rate of data flow from new sensors will be so great that digital analysis will be very expensive and time consuming. On the other hand, visual interpretation will be improved due to the better spatial resolution. The workshop group agreed that digital analysis should be used where and when an improvement in interpretation could be gained, but that visual interpretation would probably be the prime information extraction process for some time to come.

Many remote sensing studies are pilot projects. They often show favourable results, but seldom get to an operational mode. Efforts must now be focussed on evaluating why this situation exists. This should be the next thrust for land monitoring and remote sensing.

SUMMARY

Remote sensing is a very important monitoring tool. Over the last few decades, the use of air photography has played a key role in land-use monitoring. After 15 years, we are on the verge of using satellite remote sensing for land-monitoring purposes in an operational sense. This is an important statement. However, conventional data should be used in conjunction with satellite imagery to provide an improved understanding of the satellite data.

C. THE ROLE OF AUTOMATED INFORMATION SYSTEMS IN MONITORING

Chair: Larry Martin
Rapporteur: George Jackson

Ian Crain
Michael Dillon
Norman Drummond
Geoff McDonald
Neil Seely
Craig Taylor
Leigh Warren

QUESTIONS ADDRESSED

- What types of computer capabilities are required to conduct land-use change and land-degradation monitoring? What types of software are available? What type is needed? What automated information systems are available and being used?
- What is the role of micro computers in monitoring programs?
- How can an automated information system be used to provide monitoring data and background material to those responsible for policy decisions?

WORKSHOP DISCUSSION

There is a wide range of computer capabilities available today. The main problem is to match the hardware and software to the needs of resource managers. In addition, it must be recognized that the data supply is ahead of our ability to analyze it, particularly in utilizing modelling concepts. As computer-trained personnel move into middle-management positions, computer-integrated concepts and systems will become **basic management tools**. Computer models, flowing from the increased use of this capability, will provide forecasts of the future while, at the same time, retain a historical record.

E.W. Manning

Similkameen Valley, British Columbia

With the development of diverse data sets there is a need for all agencies within a discipline to recognize and utilize **common standards** in the collection and interchange of data. Furthermore, the lack of an accurate digitized map base is a limitation to the creation of geographically referenced data sets. Some data bases may fail cost-benefit reviews either because problems exist with the data or the results do not justify such a high capability system.

There is concern that the confidence level attributed to computer data is not fully warranted. Those responsible for data collection and documentation must ensure that this confidence is not misplaced. Frequently, complex data collection and analysis procedures are designed to utilize the full capability of the automated system, and not just to provide the desired answer. While this situation will likely improve with experience, it can be costly in dollars and manpower.

The use of **micro computers** will increase rapidly at the local or field level for the following reasons:

- they facilitate local input and supervision of data;
- they are capable of receiving data for the local area from a main frame system, for example, LANDSAT data;
- they can form part of a network that allows for the interchange of data and access to a main frame as needed, thereby increasing flexibility;
- they allow for security of data, although there is a danger that data may be locked away and become non-accessible;
- they lend themselves to the use of models, often applied to limited studies in specific problem areas; and
- data can be transformed and interpreted by a new generation of computers, with micro computers facilitating this interchange.

A number of automated information systems such as CANSIM[1], CANSIS[2], and CLDS[3] already exists. Each represents a form of monitoring. However, there is concern over the form and substance of the data from these information systems in terms of user needs. It is appropriate to ask if new data will be **compatible** with existing data in the system? The potential also exists for using data collected by others for another purpose. Subdivision plan applications used to monitor the conversion of agricultural lands to non-agricultural uses are an example of this.

[1]Canada Socio-Economic Information Management System, Statistics Canada.

[2]Canada Soil Information System, Agriculture Canada.

[3]Canada Land Data System, Lands Directorate, Environment Canada.

SUMMARY

The automated information system can provide historical, comparative, and analytical data quickly and concisely. It will also provide a base from which to measure land-use changes as they occur. Finally, the automated information system can be adapted to Teledon-like applications to provide agencies and individuals with data both in a useful form and at a low cost. For researchers involved in land-use change and land-degradation monitoring, the automated information system is an invaluable tool.

D. THE POTENTIAL OF EXISTING DATA SETS FOR MONITORING

Chair: Barry Smit
Rapporteur: Anne Kerr

Corwin Cambray
Robert Cournoyer
Ralph Krueger
Ted Manning
Doug Mazur
George McKibbon
Greg Roberts
Michael Troughton

QUESTIONS ADDRESSED

- What data are available and useful for land-use change research? Where are the gaps?
- What opportunities and limitations are associated with the use of existing information for monitoring (e.g., use of assessment rolls in land-use change research)?
- What are the essential criteria and considerations for a data set to be useful for monitoring purposes?
- What techniques are available for integrating and using available data sets to overcome such inherent problems as spatial and temporal inconsistencies and incompatibilities?

WORKSHOP DISCUSSION

A list of 22 existing data sets were identified which could, potentially, have some utility in a land-use change monitoring program (see Table 1). **Criteria** are needed to establish whether the above data sets are useful for monitoring purposes. The following nine criteria were considered essential:

- **Replicability** — data must be available for more than one time period and there must be internal comparability of data and its units of measure over time;
- **Suitability** of the variables and data for monitoring purposes;
- **Geo-coding** or some spatial reference system;
- **Completeness** of data for units of investigation;
- The **scale** of data must be appropriate for the type of monitoring required;
- The data must be **objective**;
- The **cost** to the user in terms of money, time, and expertise required for data collection;
- **Availability** of the data in terms of ease of access and confidentiality; and
- **Retention** of the data sets for specified time periods.

G. Greenberg

Monitoring for Change Workshop

The attributes of the 22 data sets were discussed in relation to these essential criteria. Three existing data sets met a sufficient number of the criteria to be considered useful for **land-use change monitoring**: census data, air photographs remote sensing, and assessment rolls. The discussion below focusses on the problems and the potential of these three data sets.

The **Statistics Canada Agriculture and Population Census** data set is one of the best available tools for indicating national land-use trends. It provides a good data source for broad, aggregate monitoring and is reliable to at least the sub-provincial level. However, changing units and variables over time cause some difficulty regarding replicability and completeness. Spatial reference is not always uniform, particularly in rural areas. At detailed levels of information, some data are subject to interpretation and there are some built-in inaccuracies which impair objectivity. Census data cannot be used to measure the intensity of land use or the nature of land-use change.

Air photographs remain one of the best data sources for monitoring both land-use and land-degradation changes. In the past, there has been good, broad, sequential air photo coverage of the country and air photographs have been useful for both broad surveillance and detailed types of monitoring. For times-series analysis, historical air photographs are avail-

Table 1
Existing Data Sets with Potential for Monitoring Purposes

- Statistics Canada census information, both population and agriculture
- Forest inventories
- Assessment rolls
- Canada Land Inventory (CLI) capability maps and land-use maps
- Soil surveys
- Cadastral maps / land titles system
- Hazard maps (shoreline, floodplain)
- Climate recording-station data
- Crown land records (tenure, registration)
- Regional and local planning records
- Ecological land classification surveys
- Northern Land Use Information Mapping Series (NLUIS)
- Air photographs / remote sensing
- Coastal zone maps
- Knowledgeable individuals (human resources)
- Environmental Impact Assessment (EIA) data bases
- Royal Commission reports
- Agency records, eg., Canfarm, Farm Credit Corp., Wheat Board
- Utilities (servicing records)
- Business directories
- Sub-surface resource inventories (held by companies)
- Geological maps

able although not always at desirable scales. In addition, there is a problem of sparse coverage in rural areas over time. Replicability may be a problem in the future since aerial photography is now being flown for specific areas or interests rather than in the block coverages of the past. This is due to the increasing costs associated with flying and air photography purchase. However, other **remote sensing** mediums such as LANDSAT and RADARSAT may provide more sequential coverage over time, although sophisticated equipment and expertise are added costs associated with image analysis.

Data sets associated with **assessment rolls and Crown land records** have significant potential for monitoring. Although updating is carried out, it is not necessarily spatially consistent. Geo-coding is consistent within some provinces, but not between provinces. In some areas, assessment data are not computerized making it difficult to locate information quickly and easily.

Although assessment rolls provide very detailed data in terms of geographic units, the variables themselves are aimed at a broad, surveillance level. If a few questions could be added to the data forms to increase the detail of the variables, assessment rolls and Crown land records/titles could have extremely high potential for monitoring. A problem, however, particularly with Crown land records, is the lack of retention of historical data. The records are updated frequently and no data are kept to retain information for past periods. In addition, data availability may become a problem with the apparent trend towards heightened confidentiality of assessment roll information.

Potential data sets for **monitoring land degradation** were discussed briefly. The nine criteria for establishing the utility of existing data sets for monitoring land-use change were considered essentially the same for land-degradation monitoring. The following were identified as potential data sets for land-degradation monitoring: **remote sensing/air photographs**; **knowledgeable individuals**; and **hazard maps for local areas**. For land-degradation monitoring baseline data are required. Therefore, **soil tests** and **ecological land inventories** were considered useful for establishing baseline data to support future monitoring.

SUMMARY

Agencies undertaking inventories must be made aware of the **potential** their data sets have for monitoring purposes. Little additional effort may be required either to change the way in which data are recorded or to add a few variables to make the data useful for monitoring. Examples include the repetitive use of sample plots in forest inventories, and the addition of a few variables to assessment rolls. Existing data sets presently used for monitoring, that is, census and air photographs, should be continued in the future. They provide a continuous record of land-use change over time. These should not be replaced, but rather complemented by new technologies designed to assist monitoring programs.

E. STANDARDS FOR MONITORING CHANGE AT REGIONAL, PROVINCIAL, AND NATIONAL LEVELS

Chair: Jean Séguin
Rapporteur: Daniel Paquette

Paul Brown
Alistair Crerar
Brian Haddon
Monique Léonard
Dale Sudom
Jean Thie
Gordon Weetman

QUESTIONS ADDRESSED

- What criteria should be considered when initiating land-use change monitoring at various levels (e.g., data compatibility, standard classifications)?
- What is the appropriate level of detail for monitoring land use and land degradation in Canada?
- What standards need to be established to ensure monitoring meets the needs of land planners and managers?
- Are common standards feasible for national, provincial, and local needs?

WORKSHOP DISCUSSION

There was general consensus in the workshop group that standards were required for monitoring land-use change at regional, provincial, and national levels. However, it was also recognized that all levels of government do not require the same amount of detail to provide the required information. Hence, the same monitoring standards are not appropriate at all levels. Within each level, emphasis must be placed on **compatibility and comparability** of data. In addition, compatibility between classification systems was identified as a key element to standardization. This must not, however, reduce the quality of the information at any level. It was also suggested that standards be established scientifically rather than on an economic or social basis. It was recognized that effective land-use and degradation monitoring cannot be reached through standards only. **Methods and procedures** of data gathering must also be developed and updated.

Standards should be defined with regard to specific needs. To this end, **research priorities** must be identified at each government level. In practice, those engaged in monitoring activities develop distinct concepts which often cannot be applied elsewhere. For example, forest productivity may be defined in terms of a forest's wood production capacity, the value of standing trees, or the supporting soils. In addition, the meaning of forest land productivity may vary according to province. Similarly, soil degradation, wind erosion, and soil erosion may differ in both meaning and importance from one region to another. These definitions must be standardized to maintain comparability.

To develop standards that will meet the needs of each level of government, scales must be established which reflect the detail of information required. Current land-use and land-degradation monitoring information must be made available to all land managers and decision makers. Accordingly, some form of **coordination** between the various levels is necessary. In this way, politicians and decision makers may be made more aware of land-use change and land-degradation trends from coast to coast, enabling better regional and national perspectives.

SUMMARY

During the workshop session, it was agreed that standards for monitoring land-use change which stress data compatibility and comparability are needed both within and between the various levels of government. Furthermore, land-monitoring information from these levels must be made available to managers, politicians, and decision makers. To achieve this objective, improved communication and coordination are required.

P.C. Rump

National Capital Region

F. SHOULD LAND-USE AND LAND-DEGRADATION MONITORING PROGRAMS BE INTEGRATED?

Chair: John Pierce
Rapporteur: Wendy Simpson-Lewis

Alfred Birch
Michael Brklacich
Chris Bryant
David Gierman
Terence McRae
Ken Redpath
Martin Tabi

QUESTIONS ADDRESSED

- Is it appropriate to integrate land-degradation and land-use monitoring? What are the advantages and disadvantages?
- What are the relationships between land-use change and land degradation? What research is required to study these links?
- Are different methods and techniques required to monitor land degradation on various land uses?
- If integration is desirable, how can it best be achieved?
- Which land uses (or processes) contribute significantly to land-degradation problems?

WORKSHOP DISCUSSION

The workshop group provided a positive response to the overall question of integrating land-use and land-degradation monitoring programs. One priority is to better organize and coordinate all levels of government, private industry, and universities to maximize available resources and to share existing knowledge, data bases, and monitoring techniques. Having arrived at this consensus relatively quickly, attention was focussed on the somewhat more philosophical questions which follow. Such an opportunity to step back and take a broad perspective was welcomed by the group.

Obviously, land-use change and degradation are related. Furthermore, land and water can not and should not be separated. Therefore, the study of land/water problems and the development of solutions must be integrated. Virtually all land uses have cross-sector, two-directional degradational impacts on other land uses. The nature of these relationships will vary across Canada and across land-use sectors depending on the varying physical, political, social, and economic influences. Generally, however, the group believed that there is a direct or symmetrical relationship between land use and degradation. For example, in western Canada salinization precipitates agricultural land-use changes. Selected crops can no longer tolerate the salt, hence, cropping practices change. More frequently, however, it is land-use changes or poor land-management practices that contribute to degradation problems such as salinization or wind erosion.

The same land-use degradation relationships do not necessarily exist across Canada. The salinization land-use linkages of the Prairies are not present in eastern Canada. Furthermore, it can be hazardous to extend specific research results or relationships from one ecological area to another.

Due to complexities in ecology, society, economics, and government organization, no one person's or agency's perspective is totally comprehensive. A management system or forum is needed that combines or integrates all relevant views, because many of the causes and solutions can be found in other disciplines. Thus, in order to address land-use change or degradation problems and their inter-relationships effectively, a better appreciation of the broad social, economic, political, and educational context of these processes is required. It is these factors that lead to decisions which contribute to undesirable changes or degradation and therefore should be the focus of more research. By better understanding the barriers

E.W. Manning

Severe gullying, Milk River Watershed, Alberta

to employing conservation techniques, the removal of these barriers through changes to policy, financial, or educational programs can be effectively addressed.

There is a difficulty in understanding the broad context in which these land-use change and degradation processes occur. The sector approach used to manage land resources is easier administratively, but this approach clashes with actual resource problems which refuse to remain neatly partitioned. Even professionals in different fields are compartmentalized. The different disciplines must learn to work together more effectively in order to resolve land problems and issues.

It is important to remember that circumstances change. Land once viewed as permanently degraded may be reclaimed with new technology, irrigation, or a change in perception. Degradation has a negative connotation; perhaps we should speak of land conservation. When seeking funding or support it may be more politic to talk in terms of the more positive words conservation and sustainability.

Other issues discussed by the group included:

- the success of universities in producing qualified graduates with relevant research backgrounds;
- the direction of funding to focus research on priority areas;
- the possible change of research orientation if private industry becomes more involved in funding research;
- coordination of issue/problem identification with government/industry funding of university research;
- maximization of monitoring efforts amongst the various players for optimal results;
- ways to improve communications between land-monitoring data producers and their clients; and
- the more effective lobbying of decision makers (both grass-roots land users and senior bureaucrats).

There are probably as many techniques as there are types of degradation and land use. Some problems are very scale-dependent. Loss of organic matter in topsoil cannot be monitored in the same way salinization is studied. However, overall the requirement is to devise monitoring techniques that are economical enough to give reasonable and rapid estimates of large scale land-use changes or deterioration of land quality. The more cost-effective the techniques, the more widely they will be used. This will assist the rapid targeting of priority areas, research, and funding to enhance the understanding of the nature and scale of problems. A monitoring program sufficient to assist in effectively focussing research need not be ponderous. Decision makers and politicians need indicators, if not answers, quickly. Overviews will help focus attention on problem areas where a solution response is most urgently required.

Basically, the integration of land-use and land-degradation monitoring is a political or administrative problem. There is a major challenge in coordinating federal, provincial, and municipal government programs, and in turn, linking these efforts with those of private industry and universities. Existing committees are not being used to their maximum effectiveness to coordinate the identification of issues, the spatial areas of concern, and the methods of integrating monitoring efforts.

The problem of integration is less acute at the research level. However, researchers or planners must work within the existing political and sectoral structures. Within any level of government there are differences of opinion between sector departments, each one having different priorities. As land-resource conservationists, however, we have to become better salesmen. We must promote the issues of land-use change and degradation as priorities, and the use of monitoring to address these issues. And, we must be prepared to promote conservation viewpoints in terms meaningful to decision makers in sector agencies. The contribution of the land resource to the sustainability of jobs and Gross Domestic Product (GDP) may be appropriate starting points. At present, there is little information available on the socio-economic ramifications of failing to conserve the land base.

Probably there are lessons to be learned from other countries such as the United States on how to manage land-use and land-degradation relationships. The process of soil degradation and the contributing socio-economic or political factors must be known before it is possible to determine how land-user behaviour can be changed. Land-use and land-quality changes are universal problems. Other approaches or experiences could assist Canadians in charting future strategies.

Who has the role as facilitator to draw people together to enable the integration of monitoring systems, and indeed, all players involved? Someone must link, where necessary, the soil specialists, social scientists, political scientists, land-monitoring experts, and the decision makers, all in an effort to achieve wise land use and management. How this may be achieved will be addressed by later workshops at this conference.

Land activities themselves, such as forestry and agriculture, are not the source of land-degradation problems. Poor land-use practices and non-conservation activities come about as a result of technological change, government funding and policies, global commodity markets and politics, and other pressures. For example, the amount of prairie land devoted to wheat has increased because of the Canadian Wheat Board quota system. Some of this land is inappropriate for wheat production, and unintended but negative impacts such as the drainage of wetlands and soil degradation have occurred.

It is important to remember that good land management may be difficult if the land users are in a marginal economic situation. Therefore, any approach must include emphasis on developing economically-viable conservation practices, and monitoring techniques that can be implemented in conjunction with educational efforts.

Change is not necessarily bad. Some technology, some land-use changes, some policy alternatives can reduce undesirable land uses and degradation. We should be careful not to view all change as negative.

SUMMARY

In summary, there is obviously no single solution to such complex physical, political, economic, and social issues associated with land-use change and land degradation. The key is to make people aware of the problems, identify priority areas, lobby for support, target resources, and implement appropriate strategies effectively. At the same time, the essential communication network among land users in all sectors, including scientists, policy analysts, politicians, private industry, universities, bureaucrats, and others must be maintained. Integrated land-use and land-quality monitoring forms an integral link to resource conservation and will be achieved most quickly and efficiently through improved cooperation.

IV

Strategies for Cooperation

Papers
Workshops

THE SIGNIFICANCE OF COOPERATION IN RESOLVING LAND-DEGRADATION PROBLEMS IN CANADA

John Girt

The basis for cooperation and the specifications for an effective monitoring system to address land degradation are similar to those for land supply, and should be based on the information requirements of the decision makers involved. Although it can be assumed that any cooperation required to develop such a monitoring system will be forthcoming, it is much more challenging to design a system to meet potential clients' needs.

INTRODUCTION

This paper concentrates on monitoring requirements rather than on the theory of public and private intervention and response to the land-degradation challenge. The latter will be clearly described in the specifications laid out for a monitoring system. As well, this broader issue, which involves questions of research and information needs, existing policy adjustments, etc., will be discussed at other conferences such as the Agricultural Outlook Conference in Ottawa (December 1985).

Land degradation is a nebulous, subjective concept. The ecosystem at any point in time, with or without man, is never static or stable, though it may be in a form of equilibrium. Degradation implies change in a direction away from where we want to be — but, where do we want to be? It is certainly possible to measure some changes in land, soil, and water characteristics through time, but which ones are important? For each one, when does change become a crisis? When can we be indifferent or satisfied? Furthermore, how do we determine whether an action that degrades a natural resource from one perspective, but improves it from another, is a problem or a solution?

At this point, we may be reminded of Pogo who once said in the middle of the swamp, "why do we stand here confronted by insurmountable opportunities?" We have a great knack for stabbing ourselves in the foot by our inability to work consistently through the maze of interdependencies in a system. This is because we never design systems that will help us to achieve this. What is resource degradation to one interest group in society is an improvement to another. We stumble from crisis to crisis. For example, after years of uncontrolled, frontier-type resource utilization, the day arrives when one individual, in attempting the same type of consumption, is challenged by organizations and individuals unheard of before. He is labelled socially irresponsible in wanting to make his change at the wrong place and time. Therefore, not only must we build a system which will enable us to look at sectoral problems, but we must also do it in an anticipatory mode.

Frequently, not only do we have a very imprecise idea of what is important, but our information systems seem to be designed to precipitate highly moralistic conflict on theoretical supply problems, rather than to converge on ideas about demand and supply management of the sectoral requirements that the land base provides. Each sector of society, for example, agriculture, mining, recreation, etc., attempts to use the natural resource base according to a path of development that, although it may or may not be both commercially and environmentally sustainable, is based on knowledge, prices of inputs and outputs, regulations, and competition with other sectors over access to resources. Conceptually, land supply and land degradation are similar supply-based problems; both are concerned with the flow of land, or important components thereof, in response to, or in conflict with, sectoral or broader interests.

D. Coleman

Soil conservation practices, Ontario

The following are recommendations about monitoring land degradation:

- it should focus on the environmental and associated economic impacts of specific paths of sectoral development;
- it should be based on measures that are of relevance to more than one sector or interest group so that the system will promote informed discussion of trade-offs and strategies to prevent degradation within a market-oriented, development framework, and will avoid collision courses between conservation and development objectives;
- it should provide information on the actual and potential cumulative impact of small, individual sectoral-based actions in both current and forecasting modes; and
- it must be cheap and effective.

There are no known existing monitoring systems that meet these requirements for one user, let alone the multitude that should be concerned with soil degradation.

SECTORAL IMPACT FOCUS

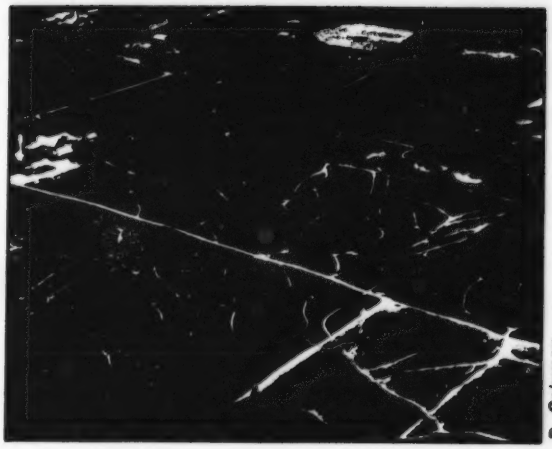
There are two paradigms used to address environmental issues — the popular one that does not work very efficiently, and the alternate one that should work if only all decision makers would focus on it.

Paradigm 1: to study environmental issues separately from those of economic development.

Paradigm 2: to focus all policies and activities towards commercially-viable and environmentally-sustainable development.

Few would promote the first over the second, but few practise the second rather than the first. One factor contributing to this inconsistency is that problems tend to be monitored and not causes. There is also a tendency to monitor physical problems and not their economic, and hence direct, developmental effects. Scientific reductionism is a barrier to progress. Physical scientists will fervently maintain that the physical state of the resource base is not yet known. Although this is true, we know even less about the implications of the 80% or 90% that we do know. Please **monitor the effects of specific practices on the environment in both physical and economic terms** if you wish to improve the effectiveness of monitoring. This may mean that, for instance, the environmental impacts of corn production are monitored in economic as well as simply physical terms, that is, in terms relevant to those interested in corn production.

Obviously, a monitoring system cannot answer all questions that may be raised about degradation. It must, however, be able to provide sufficiently quick and accurate estimates of degradation in relation to specific activities at varying geographic scales. Ideally too, it should provide projections of the following variety. What changes could be expected from the present state if we did nothing or had something specific in mind?



D. Coleman

Agricultural drainage near Stratford, Ontario

INTERSECTORAL COMPARABILITY

Intersectoral comparability requires the following specifications in addition to those discussed above:

- the need to ensure that monitoring systems are in place for competing uses, for example, between agriculture and wildlife. From an agricultural perspective, all other issues, including urban competition with agriculture for land supply, seem insignificant from a national perspective;
- that the results of monitoring systems for different sectors are expressed in terms relevant to making informed trade-offs and decisions that will further the efficiency of natural resource use;
- given that different sectors or groups will have an interest in results at different levels of aggregation, any monitoring system should have the ability to produce results quickly and cheaply to meet different clients' needs; and
- that any monitoring system must provide this information in both a commercial and environmental context, otherwise it will not promote informed resolution of environmental conflicts or pressures.

A SOLUTION SET

What has been described is quite a challenge, beyond one group's ability to implement because of the high level of sector-specific technical input that is required, and the need at the same time to be knowledgeable about sectoral development priorities. The key appears to be **to define clearly what needs to be coordinated** and what can be the responsibility of specific groups.

Following are some suggestions for what should be coordinated by some multisectoral agency:

- **Measures** — a scanning and quality control function to identify differences between monitoring systems thereby identifying when satisfactory intersectoral comparisons cannot be made; and
- **Reporting** on the **state of the environment** in relation to natural resource development, that is, a consolidation of what is being achieved or caused by all sectors. This does not imply the need for a consolidated monitoring system, only regular reports from sectoral monitoring systems. It may require the ability to detect intersectoral conflict to keep everyone honest.

The nature of sectoral monitoring systems may vary intersectorally because of different responsibilities of the various levels of government. The agricultural sector has a well developed system. The federal/provincial Institutes of Pedology and the Canadian Agricultural Services Coordinating Committee (CASCC) system provide an effective implementation and consultation framework respectively. The system's weaknesses, which are presently being addressed, include an overemphasis in monitoring pedological characteristics and an associated lack of input from crop production and agricultural development specialists. A better organized system of potential and actual user feed-in and feedback is required, involving all levels of government and the private sector. However, in spite of this criticism, the system has just completed a detailed economic assessment of the impact of agriculturally-derived soil degradation in eastern Canada and British Columbia, along with some fairly crude assessments of extra-sectoral impacts.

CONCLUSION

In conclusion, some further issues can be raised. First, the appropriate role of government departments in monitoring needs to be considered. Is monitoring a legitimate function of a department where the political head has policy-making responsibilities, or should another type of public agency which reports to the Prime Minister be responsible for it? Second, how much can be privatized? For efficiency, monitoring systems must be targeted. This implies changing priorities as issues change, something quite alien for bureaucracies to inflict upon themselves. Third, how much can we rely on reporting by private land owners and private groups? For example, why not use a sample of farmers as the basis for an indicator-based broad soil-degradation monitoring system? This could serve two purposes. First, it would assist the producer, who is ultimately responsible for production practices that sustain or degrade the resource base, to measure the impact of his own activity. Second, it may reduce the cost of monitoring at more aggregate geographic scales. The issue is not whether cooperation is needed to monitor land degradation, but first and foremost, the design of something useful, of good value for money, and implementable. It is safe to assume that cooperation will then follow.

John Girt is the Director of the Program Coordination Division of Agriculture Canada's Regional Development Branch in Ottawa.

Response from the audience:

Gerry Lucluk: You have indicated that you see a prime need for monitoring agricultural uses versus wildlife, yet most of the present discussion seems to indicate that the prime users of these types of land/data systems are in the urban/agriculture interface sector. Where do you derive the assessment that wildlife and agriculture are prime competitors for a resource base?

John Girt: I agree that most of the users of land-monitoring systems, at this point in time, have been planners. This supports my whole thesis — that, in fact, present monitoring systems may be useful for planners, but they are not really servicing the needs of other client groups.

To address the agriculture versus wildlife part of your question, we can anticipate that Canada and the United States will be signing a North American Waterfowl Management Plan. The political pressure will then be to protect migratory birds, particularly the mallard on the Prairies. Therefore, I am just anticipating that there will be strong pressures and a lot of exposure regarding the drastic decline in bird populations over the last 10-15 years. This will precipitate the need for improved monitoring. It will also precipitate a collision unless work starts on a system to identify where problems can be solved that protect as much of the agricultural interests and the birds' interests as possible. I would also argue that another problem we can anticipate concerns water supply. Soon there will be a conflict between agriculture and its impact on both ground water and surface water. This is a problem that should be anticipated and addressed. However, one does not address it by looking at it solely from an agricultural point of view. It must be tackled multisectorally and from the point of view of converging upon a solution that satisfies everyone's needs as much as possible.

Gerry Lucluk: This question is related to process and applies equally to all sectors. You have implied that people who monitor land automatically provide advice to the ultimate users of this information. Is that necessarily so?

John Girt: In terms of the person that actually does it — no; but, in terms of the information that should be provided — yes, in the sense that information must be provided that is relevant to the target groups whose activities are being monitored. The results of monitoring must be relevant to these groups, as opposed to being strictly relevant to the scientist who is doing the monitoring in the first place.

STRATEGIES FOR COOPERATION FOR FUTURE LAND-USE CHANGE RESEARCH

Alistair Crerar

In undertaking effective research on land-use change, researchers must consider social and economic elements in addition to the physical dimensions. This paper indicates that municipal assessments, which are collected by all provinces in Canada, are an existing data source where physical, social, legal, and economic information related to land use is collected in an integrated fashion.

It is suggested that the federal government, in conjunction with provincial municipal affairs departments, conduct a review of all provincial assessment procedures to identify possible tools for monitoring land. Through cooperation and coordination, this existing data source could provide the link between physical and socio-economic factors necessary to improve progress in land-use change research.

INTRODUCTION

The principal agent of land-use change is, of course, humankind. The term **land use** itself implies the agent. Land is defined according to its utility to people. If it is usable it is valuable, and the higher the potential return the more valuable the piece of land. Therefore, if effective research in land-use change is to be undertaken, all three of the following elements must be considered: **physical**, **social**, and **economic**.

Major research efforts have concentrated on the **physical environment**. Although there is much more to be known and analyzed, the physical aspect is not the major barrier to the improvement of land-use practices. The requirements to ensure sustainability are reasonably well known. At present, improvements in land-use practices are hindered by social and economic factors, and this is where our knowledge base is weak.

E.W. Manning

Rocky Mountain Foothills, Pincher Creek, Alberta

Social considerations constitute an important element of land use. If, for example, a subsistence farming lifestyle were still **socially** acceptable to Canadians, much of the abandoned farmland in the Maritimes, northern and eastern Ontario, and Quebec would be utilized. However, these areas are reverting to bush. Such a lifestyle is not acceptable to Canadians, though it would be completely satisfactory to two-thirds of humankind.

Social factors include **political** and **legal** elements. One of the major advances in land-use research occurred when Raymond *et al.* (1963) combined soil, land use, and land ownership information in Prince Edward Island. The resulting synthesis of agricultural, forestry, and recreational use, as well as the integration of stewardship, advanced the understanding of land-use change processes. That research breakthrough has not been repeated or extended. Important questions remain concerning land-use patterns associated with a) corporate farmers versus beginning farmers; b) land held speculatively at the fringe of cities; and c) short- and long-term leases on land. Although subjective assessments of the impact of these factors on land use are numerous, we have little analytical data relating physical nature and use within cadastral survey lines.

Social and **economic** information are closely related. It is impossible to try to understand or explain land use without an appreciation of **resource and land economics**. Furthermore, the economic knowledge base is inadequate. The areas where land-use research really needs sound data and perceptive analysis would include, for example, the impact on land values of zoning, soil degradation, and an alfalfa rotation over a 15 year period.

Resource economics is also a critical parameter. It is futile to recommend grass or fodder cover for problem soils unless

there is a market for cattle. Similarly, maintaining a woodlot presents a problem unless there is a market for lumber. Resource economics is the type of basic research that needs to be undertaken to cover all aspects of land use, in all parts of the nation. It is an obvious candidate to be undertaken by the federal government.

MUNICIPAL ASSESSMENT DATA

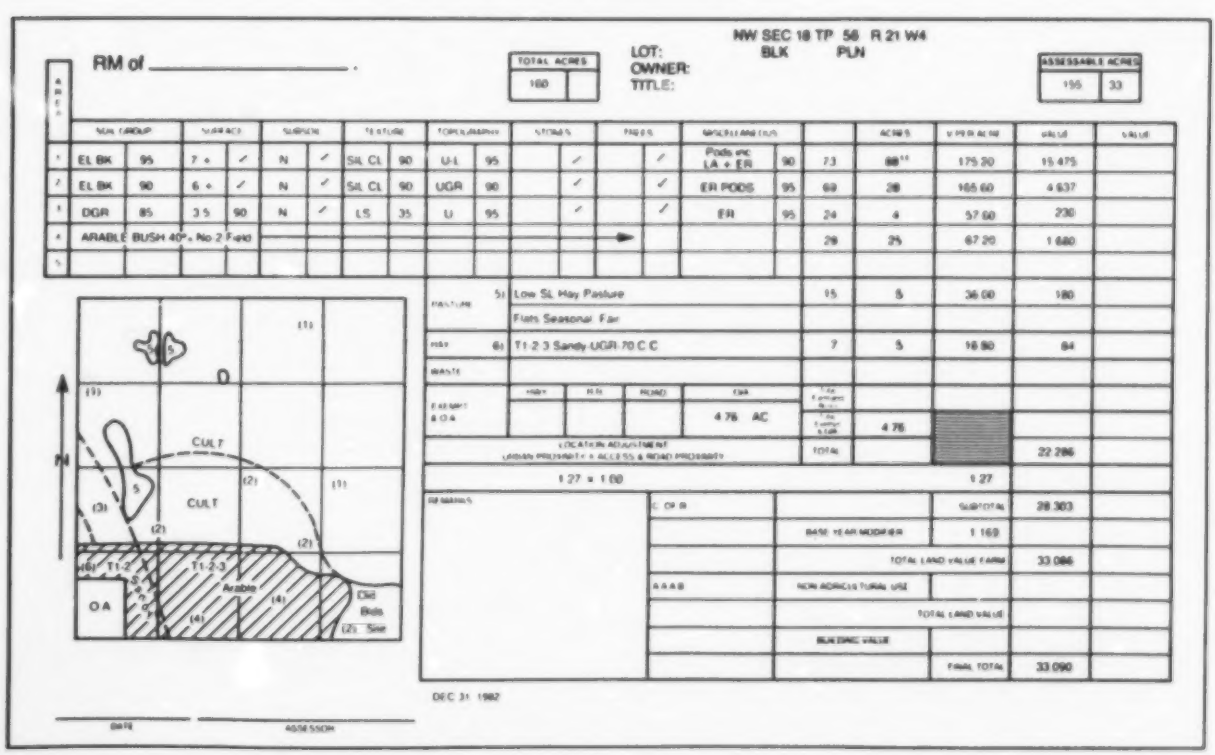
For the **social, legal, economic,** and **physical interface with land use**, the best source of data exists at the municipal level. Municipal assessors do more land-use mapping than anyone else. Furthermore, it is completed in detail and with quality control because the information is subject to yearly challenge by the landholder in a Court of Revision. Normally, municipal assessment data are subject to a regular updating procedure and, quite frequently, archival material is available. It is, of course, time series material that is essential to establish patterns of change. In Alberta, reassessment occurs every five years.

The kind of material available can be illustrated by reference to a farmland assessment form (*see* Figure 1), which is prepared for every quarter section used for agriculture in the Province of Alberta. Each of the squares on the map represents 10 acres. Details to a level of approximately 1 acre are shown. The objective of farmland assessment in Alberta is to establish the **value of land in agricultural production** — not the market value, but the capitalized value of the net agricultural production capable of being obtained from every field. The quarter section illustrated is owned by a chemical company, but because it is used for agriculture it is assessed on that basis.

Alberta has a maximum agricultural value of $425 per acre which is adjusted periodically. The assessed value is 65% of this maximum. At the time the assessment for Figure 1 was prepared (1982), the maximum value for the province was $365 per acre. However, although this value changes, the object of assessment is to identify the relative value of each field in Alberta. To this end, each field is rated against the best field in the province on the basis of qualities considered important to the potential returns from agriculture. Qualities assessed include soil group, surface characteristics, subsoil, soil texture, topography, stoniness, amount of bush, and other miscellaneous physical factors. These qualities, rated as percentages against the best field, are multiplied to provide an overall assessment in relation to production in that best field. In the example provided, the field was found to be 73% as productive as the best field.

Much detail is collected in the land-assessment process. The location of sloughs, bush pasture, buildings, and cultivated land in relation to physical elements are all determined. The important point is that this data exists for all 312 000 agricultural quarter sections in Alberta.

Figure 1
Alberta Farm Land Assessment Form



RECOMMENDATIONS

Although each province collects slightly different assessment information, the data is administered by the Department of Municipal Affairs in most provinces. As well, standardized information is collected by Statistics Canada from every municipality across the nation. With this in mind, it is suggested that a **review of the rural assessment procedures** of all the provinces be undertaken by concerned federal departments (Environment Canada, Agriculture Canada, Statistics Canada), in conjunction with provincial municipal affairs departments. The review should rate rural and agricultural assessment procedures in terms of their applicability for recording land-use information.

Each year the senior assessment officials from the provinces and territories meet for three days to discuss assessment policy. It is suggested that the question of monitoring land-use change through the use of municipal assessment data be placed on their agenda. Perhaps, through offers of technical assistance or resources, a useful monitoring tool could be designed and standardized according to the assessment approaches of the province that ranked the highest in the provincial review analysis. A cautionary note must be added. Land-use change researchers cannot expect assessors to collect information in ways most convenient for land-use change research.

Assessment represents a data source where physical, social, legal, and economic information is collected in an **integrated** fashion. Such information, collected for equitable municipal taxation purposes, is recorded, checked, and stored by thousands of assessors in thousands of municipalities. However, because it is not collected in exactly the way land-use researchers would like it to be, it tends to be ignored and overlooked. It should not be. The potential exists for relating the physical base to the decision-making unit, the farm. Perhaps assessment data represents a way to gain understanding and accuracy regarding predictions and forecasts. Through cooperation and coordination, land-use research could blossom by examining and utilizing this data source.

Alistair Crerar is the Chief Executive Officer of the Environment Council of Alberta.

REFERENCE

Raymond, C.W., J.B. McClellan, and J.A. Rayburn. 1963. *Land Utilization in Prince Edward Island*. Department of Mines and Technical Surveys, Geographical Branch Memoir 9. Department of Energy, Mines and Resources, Ottawa.

Response from the audience:

Bruce McLean: I hope that more provinces will adopt an assessment system like that in Alberta.

Alistair Crerar: One of the attractive aspects of the Alberta approach is that it is based on productivity of the land in agricultural production. There is no relation to market value at all. If the land is used for agriculture, it will be assessed as agriculture. This provides an incentive to keep land in agricultural use — and this is a great approach.

Michael Troughton: I have two points. First, in our workshop yesterday we came to the conclusion that assessment data did offer one of the best opportunities for monitoring that we could envisage. On the other hand, I would like to point out that this is a source of data that is problematic. Over the last 20 years, the assessment process has moved from the municipal, to the county, to a regional centralized control. From an individual researcher's viewpoint, the data has become progressively poorer and less accessible. In Ontario, assessments are becoming more confidential. The researcher does not have the access privileges of the past. Perhaps government agencies empowered to use the data would have better success. For example, the levels of confidentiality that now apply to census data have also limited its utility, particularly at the level where the data might be used for degradation monitoring. Furthermore, if there is any suggestion that confidentiality is being compromised, there could be adverse public reaction.

Alistair Crerar: Assessment information goes before a Court of Revision. Therefore, it cannot be private or confidential. In agricultural Alberta, there are no secrets about your land, what you are doing with it, or its value. Equity between different parcels and quarter sections is also observed and commented upon. Perhaps it would be useful to try to switch the assessments to a productivity-based rather than a market-based evaluation. Some provinces have already adopted these approaches, so it may be a direction in which it is possible to move relatively easily.

— WORKSHOPS —

STRATEGIES FOR COOPERATION

STRATEGIES FOR COOPERATION

Chairs:	Ken Beanlands, Paul Brown, Réal Michaud, Dale Sudom, Michael Troughton
Rapporteurs:	Oliver Code, Pierre Desforges, Brian Haddon, Geoff McDonald, David Wilson

QUESTIONS ADDRESSED

- How can improved linkages between the generators and users of land-use change and land-degradation information be achieved?
- Is better coordination between agencies conducting land-use and land-degradation research desirable? Is it feasible? If so, how do we achieve this coordination?
- What can be done to ease the problem of data incompatibility between projects, programs, and agencies?
- Are government monitoring programs complementary, conflicting, and or duplicating? How can we ensure the highest level of efficiency and comprehension between these programs?
- Is there a forum for continuously sharing progress, developments, and results in monitoring land use and land degradation? If not, should one be created and what form should it take?
- What should the federal and provincial roles be in encouraging and facilitating future coordination and cooperation?

During the session on Strategies for Cooperation, each workshop group discussed two or more of the above questions. Consequently, the discussion which follows is a combination of reporting by rapporteurs from all five workshops. The main points are summarized under four headings: Communication, Coordination, Data Compatibility and Monitoring Procedures, and A Higher Profile for Monitoring.

COMMUNICATION

Generally, it was agreed that an overall improvement in monitoring approaches could be achieved through education, better understanding between information generators and users, and better coordination at all levels.

Education involves informing data users about the work and needs of data generators and vice versa. It also involves alerting the public and politicians to the importance of land-use and land-degradation monitoring. The first challenge is to inform others in the field of on-going research. A number of ideas were discussed on how to promote information exchange.

It was suggested that a group be created using the **Intergovernmental Committee on Urban and Regional Research** (ICURR). The groups mandate would include establishing intersectoral communications, providing a central registry of information on both land-use change and land degradation, and heightening the awareness of these related issues among the generators and users of the information. An **information directory** or central registry of who is involved in monitoring, and the nature of their programs, should include both the kinds of information available through various agencies and programs, and the methodologies used in those various programs. This could form the basis for a **network** among existing monitoring groups to **heighten awareness** and to **provide information**.

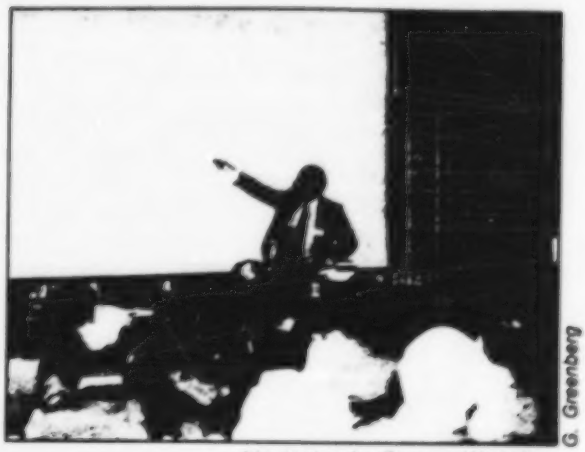
Currently, there is no specific organization which promotes information exchange for monitoring programs. To provide opportunities for current information exchange between researchers in land-use change and land degradation, it was suggested that **annual workshops** be held at the **national level**. However, to achieve results, action must also be taken at regional and provincial levels. In fact, emphasis was placed on the need for **regional symposiums** on land-use change and land degradation. These would be directed towards data

E.W. Manning

Grain and tobacco fields, Kingsport, Nova Scotia

users, such as associations of town planners, municipal engineers, geographers, and universities. It was also suggested that an informal newsletter on, for example, geographic information systems (GIS) appropriate for monitoring, would be useful. **Land/Terres newsletter** was cited as a possibility for dissemination of this type of information.

From a public dissemination viewpoint, published **information pamphlets** were recognized as a feasible way to increase awareness of land degradation and how changes in land use can affect the resource. An example of where a similar awareness-drive has proven effective is the Vegetable Producer Council of Quebec (a committee under the Quebec Department of Agriculture, Fisheries and Food) which publishes pamphlets designed to increase the awareness of soil degradation.



G. Greenberg

Monitoring for Change Workshop

COORDINATION

Parts of government monitoring programs are indeed complementary, conflicting, and/or duplicating. However, valid reasons exist for some data overlap. For example, similar programs may be established by agencies with different goals. One program may need general answers quickly, while another requires more accuracy but does not face the same time constraints. All participants were in favour of, and recognized a need for coordination. Recommendations presented in Girt's paper were recognized as applicable. The first step is to **define clearly what needs to be coordinated** and what can be the responsibility of specific groups.

It seems most efficient for each resource sector to carry out its own monitoring program, for example, forestry or agriculture. Sectors tend to monitor for their own reasons, to solve their own problems, and to express results in terms appropriate for their needs. These results are not necessarily helpful to others or to the resolution of conflicts should they arise. However, it is probable that such sectoral monitoring will be maintained.

The need for integration of resource sectors in a monitoring program is apparent in areas where sectors are competing for the same land base. It is appropriate for **land-use monitoring**, that is, the Canada Land Use Monitoring Program, to focus monitoring efforts at sectoral interfaces. **Land-degradation monitoring**, on the other hand, requires **internal integration** within individual sectors, for example, agriculture. In the case of soil degradation, complementary programs within the same sector should exist within the different levels of government. The integration of physical, social, and economic factors in land monitoring was reinforced in the workshop discussion. This is necessary to maximize the use of monitoring information in policy and decision making.

Girt suggested that a multisectoral agency should identify differences between monitoring systems thereby identifying when satisfactory intersectoral comparisons cannot be made. At present, there is no existing agency responsible for undertaking such a task, although the Lands Directorate and various committees in the private sector, for example, the Forest Industry Committee, do offer the potential for playing coordinating roles. There are, however, many informal or indirect activities which lead to cooperation and coordination, for example, **project level cooperation**. Positive response was received from workshop participants concerning this type of involvement. Whether an issue arises from an earlier program, the federal level, or local concern, cooperation and coordination are necessary to ensure money and expertise are allocated efficiently.

It was agreed that a committee or a central monitoring agency was required to oversee this type of coordination and cooperation. It would be responsible for establishing the information registry and list of contacts suggested above. The workshop groups recognized that a number of existing groups and committees have the potential, with an expanded terms of reference, to provide a forum to discuss land-use change and land-degradation monitoring. It was suggested that technical committees could be set up under, for example, the Interdepartmental Committee on Land (ICL) and the Canadian Council of Resource and Environment Ministers (CCREM). The Canadian Forest Inventory Committee (CFIC) and Expert Committee on Soil Surveys were cited as examples of successful forums for information exchange. It was noted that a monitoring forum should include participation by members of the universities, private sector, and public-interest groups, as well as representation from all levels of appropriate government agencies. During workshop discussions, however, it was suggested that a new committee be established rather than adding land-use and degradation issues to the mandate of existing committees. Again, the CFIC was cited as an example of a good model to follow in establishing such a committee. Furthermore, it was agreed that Environment Canada should evaluate the proposal of a land monitoring coordinating committee and propose the most suitable form for implementation. However, caution was advised in establishing new committee structures. If they are not administered properly, especially initially, many good people and ideas may be lost.

DATA COMPATIBILITY AND MONITORING PROCEDURES

A concern arising from the need for coordination was that of data incompatibility and standard procedures. Spatial scale differences among the large amounts of existing information are perceived by some to be a major problem for data integra-

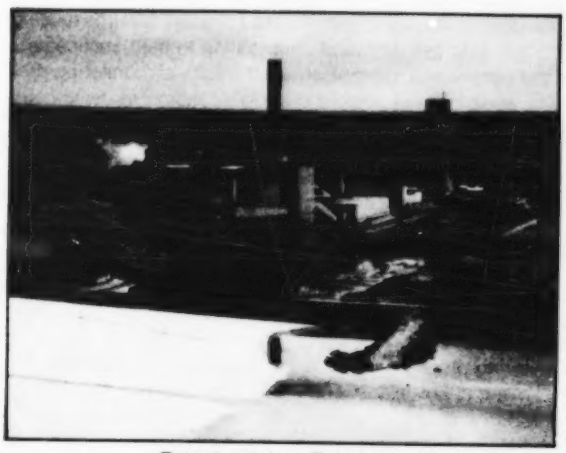
tion. This situation arises even though similar attributes may be featured at each scale. In response to this, it was recommended that **standardization of spatial scales** be agreed upon at early stages of cooperative ventures.

Although it was recognized that data incompatibility does indeed exist, many participants believed that the problem is overstated in many cases. It is impossible to develop a monitoring system to meet all needs of all users. However, to convert as many systems as possible to a more universal monitoring system, **standards** must be established and maintained. For example, there is a need to define **data collection procedures** in land-use monitoring. Although the data itself may be incompatible, if procedures and definitions are well-documented at least qualitative explanation and comparison are possible. To obtain federal, provincial, academic, and end-user interest in standardized data collection, manipulation, and storage, a marketing strategy is required to sell the concept. The idea that data bases may be useful to others beyond the originators, needs to be promoted among those specifically involved in land-use monitoring. Personal meetings with various end-users may provide feedback on what kind of data are required. Strategies to massage data that are collected to fulfill other user requirements could also be developed simultaneously. Again, it was stressed that a coordinating group, perhaps a federal-provincial committee, was needed to oversee these activities. As an initial step towards setting standards, it was recommended that the federal government take the lead in circulating potential standards for consideration by all interested parties. Involvement by the provinces would follow, recognizing that they have a large number of users of land-use data.

It was suggested that **existing standards**, for example, those geographic standards of the National Topographic System (NTS), be used as a reference for the development of land-monitoring standards. The most practical approach would probably be to first develop standards for biophysical data and then integrate standards for socio-economic parameters as a second step. It was also recommended that data standards be structured to include probable future changes, and even be flexible enough to accommodate unforeseen future changes.

In sectoral monitoring, there is a need for complementary parameters to be used to ensure some common ground in areas where a multi-sectoral monitoring approach will be required. It was agreed that a basic set of parameters for a number of sectors should be agreed upon, but these should not limit the number of variables an individual sector may wish to monitor. Common data sources such as remote sensing and census statistics can provide the basis for determining this common ground. Agencies, such as the Canada Centre for Remote Sensing (CCRS) and Statistics Canada, which currently provide these data, can complement the work of other agencies and individuals with a land monitoring interest. The Census of Canada could, for example, include questions relating human activity to the resource base. This would serve as a means of integrating different sources of land-related information.

Satellite remote sensing technology offers an opportunity to increase efficiency, compatibility, and comprehension both between programs and across sectors. Generally, the workshop participants believed that, as researchers monitoring land-use change, we must increase our use of satellite remotely-sensed data. However, the cost-benefits associated with the application of these new technologies must be known prior to their incorporation into operational land-monitoring programs. Consequently, **technology enhancement and transfer programs** such as those operated by federal and provincial remote sensing centres should be part of an overall land-monitoring strategy. Pilot studies have been completed, but these are of fixed duration and often do not incorporate further application development. In his paper, Peters provided examples from New Brunswick where the Remote Sensing Technology Enhancement Program (TEP) helped to promote the acceptance of remote sensing in land-use change detection projects in that province.



SSC Photo Centre Library

Potash mining, Esterhazy, Saskatchewan

The workshop groups emphasized the need to extend land-monitoring programs to provide a focus on future change. It was recognized that change data on trends from the past to the present are required to provide context for contemporary natural resources management. However, if land monitoring is to increase its influence on policy and decision making, it must provide indicators of future trends. Bryant's concepts of representative areas and change observatories were supported. In addition, land-tenure change was suggested as an indicator of future trends. Tenure information could be obtained through assessment rolls and perhaps selectively sampled.

A HIGHER PROFILE FOR MONITORING

There was general consensus in the discussion concerning the need to develop a **higher profile for monitoring**, both politically and publicly. To attain this, the gains and benefits of land monitoring must be clear to groups like CCREM where monitoring program results must be directed to show either positive solutions or dire consequences to the "what if" questions on land-use change. At this point, land-use change and land-degradation relationships to social and economic values have not been defined well enough to raise the political level of

interest in monitoring. Efforts must be directed towards relating land-use changes and land degradation to their implications for the economy and employment. Results of monitoring programs need to be expressed in socio-economic terms that are useful to decision makers.

It may be necessary to stress the **scarcity** of a resource, for example the fruitlands in the Niagara region, to stimulate attention. The workshop groups agreed that national and provincial levels of monitoring are required to place values such as relative scarcity and local figures into context. In this way, programs can be complementary.

Monitoring programs need to be "packaged" to appeal to the public and to politicians. The term "monitoring" may not be an appropriate one for this purpose, as it implies a long-term, technical program, with results not immediately applicable to the political time frame. The term "environmental health" was suggested to better express the utility of the process and help capture the spirit of the objectives behind monitoring. In any presentation of land monitoring, the long-term health of the environment and the economy should be referenced. Monitoring should be related to delivery mechanisms and directed to a specific spectrum of interests.

It was suggested that a policy or position paper on the importance of land-use change and land-degradation monitoring be presented to CCREM. Such a position paper should come from a professional organization that represents diverse interests (government, industry, university, etc.). In this context, the need for a monitoring agency which would present issues on land-use and degradation change to politicians was raised. An appropriate structure for such a group would be a National Advisory Council on Land which would include representation from producers, land owners, public-interest groups, and local, provincial and federal governments. Land degradation should be adopted as the primary contemporary issue of the Council. By focussing on land degradation rather than the more general topic of land-resource use, public and political support may be lobbied more effectively. Another type of agency, a National Environmental Institute, supported by public donations rather than government funds, was recommended to fulfill this role.

It was recommended by some workshop groups that land monitoring be included as part of provincial conservation strategy papers. Such papers would include input from a broad range of interests, ranging from business to wilderness groups, and would fit into the larger national context through such efforts as the World Conservation Strategy. The idea would be to build a broad base of support for monitoring the environmental health of the nation's resource lands and to build bridges between interest groups in order to work towards a common goal. With this broad base, all levels of interest would expand their awareness of land-use issues in ongoing programs.

Appendices

A. List of Participants
B. Selected Land Monitoring References
C. Glossary

APPENDIX A

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APPENDIX B

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APPENDIX C

GLOSSARY

AES	Atmospheric Environment Service, Environment Canada
ALR	Agricultural Land Reserves; provincial zoning in British Columbia to protect agricultural land
Arc/Info	Trade name for a type of GIS available from the Environmental System Research Institute (ESRI) in Redlands, California
ARDA	*Agricultural and Rural Development Act* (1966); formerly the *Agricultural Rehabilitation and Development Act* (1961)
ARIES II	A digital image analysis system available from Dipix Systems Ltd., Ottawa, Ontario
AutoCAD Software	Auto Computer-Aided Design; CAD is used on the IBM PC; CAD programs can be used to create, edit, and make hard copy, but the medium is pictures rather than words
BCGS	British Columbia Geographic System
BCLI	Canada Land Inventory of British Columbia; the CLI modified to account for B.C. soil and climate conditions
Bill 90	*The Agricultural Land Preservation Act* (1978). Government of Quebec, R.S.Q. 1978, C.P-41.1
CANSIM	Canadian Socio-economic Information Management System of Statistics Canada
CANSIS	Canadian Soil Information System of Agriculture Canada
CARIS	Trade name for a type of GIS available from Universal Systems in Fredericton, New Brunswick
CASCC	Canadian Agricultural Services Coordinating Committee
CCLU	Canada Committee on Land Use
CCREM	Canadian Council of Resource and Environment Ministers
CCRS	Canada Centre for Remote Sensing, Energy, Mines and Resources Canada
CFIC	Canadian Forest Inventory Committee
CFS	Canadian Forestry Service
CGIS	Canadian Geographic Information System
CHU	Corn Heat Units
CLDS	Canada Land Data Systems, Lands Directorate, Environment Canada; geographic, computerized map storage and retrieval systems
CLI	Canada Land Inventory; a comprehensive survey of land capability and use designed to provide a basis for resource and land-use planning (completed under ARDA)
CLUMP	Canada Land Use Monitoring Program, Lands Directorate, Environment Canada; designed to monitor the amount, rate, nature, and location of land-use change in Canada on national and regional scales and to provide assessments of the significance of land-use change from national and sustainable resource perspectives

CMA	Census Metropolitan Area; the main labour market area of an urbanized core (or continuous built-up area) having 100 000 or more population; created by Statistics Canada and are usually known by the name of their largest city; they contain whole municipalities (census subdivisions)
Comarc	Trade name for a type of GIS available from Comarc Systems in San Francisco, California
DICS	Digital Image Correction System; a method whereby LANDSAT MSS data are geometrically corrected for distortion, etc.
Digital Analysis	The computer techniques for mathematical manipulation, statistical sorting, and classification of digital data
Digital Image	The representation of an image by a finite number of discrete points
ECC	Economic Council of Canada
EIA	Environmental Impact Assessment
EOSAT	Earth Observation Satellite (Corporation); formed to commercialize the Land Remote Sensing System providing high resolution imagery and computer products from global multispectral observations
ERDA	Economic and Regional Development Agreement
FD	Floppy Disk; a thin, flexible magnetic disk on which data may be stored and manipulated and a semirigid protective jacket in which the disk is permanently enclosed
GDP	Gross Domestic Product
GIS	Geographic Information Systems; systems designed to store and manipulate data relating to locations on the earth's surface
GNP	Gross National Product
GOES	Geostationary Operational Environmental Satellite (NOAA/NASA); a meteorological satellite
GSLM	Generalized Soil Landscape Map
ha	Hectare; a metric unit of land measure equalling 10 000 square metres, equivalent to 2.471 acres
IBM PC	International Business Machines Personal Computers
ICURR	Intergovernmental Committee on Urban and Regional Research; performs information exchange for federal, provincial, and municipal subscribers
IGDS	Interactive Graphics Design System
IGSS	Interactive Graphics Sub-System
IR	Infrared
ICL	Interdepartmental Committee on Land
km	Kilometre; a unit of length or distance, equal to 1 000 metres, equivalent to about 0.625 mile
LANDSAT	Land Satellite (previously called ERTS — Earth Resources Technology Satellite); an unmanned, earth-orbitting satellite (NASA) that transmits images to earth receiving stations; designed primarily for collection of earth resources data
LEG	Land Evaluation Group, University School of Rural Planning and Development, University of Guelph, Guelph, Ontario
LMS System	Linear Measuring Set System; an electronic analogue to digital image processor

LRRI	Land Resource Research Institute, Agriculture Canada
m	Metre; the basic unit of length in the metric system, equal to 39.37 inches
Main Frame	A powerful central processing unit capable of processing at high speed large, complex software in a multi-user environment. A machine of this size will include many devices such as disk drives, tape drives and printers and usually requires a controlled environment. Computer systems personnel are required for the maintenance and operation of a main frame installation.
Micro Computer	A computer system the processing unit of which is a microprocessor; includes a microprocessor, storage, and an input-output facility
Mini Computer	A medium-cost and sized computer; does not require the closely controlled environment of main frame computers, and has a richer instruction set and is more powerful than a microprocessor
MEIS	Multi-detector Electro-optical Imaging Scanner/System; a scanner designed by CCRS, Ottawa
MSS	Multispectral Scanner; senses the electromagnetic radiation from the earth's surface in four narrow regions (bands) of the electromagnetic spectrum which are numbered 4 through 7
MUC	Montreal Urban Community
NAPL	National Air Photo Library, Ottawa, Ontario
NAWMP	North American Waterfowl Management Plan; an agreement which outlines a policy framework that provides goals for waterfowl population and habitat management in Canada and the United States
NASA	National Aeronautics and Space Administration, U.S.A.
NBDNR	New Brunswick Department of Natural Resources, Fredericton, New Brunswick (recently changed to New Brunswick Department of Forests, Mines and Energy)
NESS	National Environmental Satellite Service, Washington, D.C, U.S.A.
NLUIS	Northern Land Use Information Series; a series of maps providing reconnaissance-level information for Canada's North on environmental-social topics including wildlife, fish resources, native land use, ecological land classification, and socio-economic and cultural data
NOAA Satellite	National Oceanic and Atmospheric Administration, U.S. Department of Commerce; a meteorological satellite
NTS	National Topographic System; a hierarchical quadratic grid covering all of Canada, used in the indexing of maps
OCRS	Ontario Centre for Remote Sensing, Toronto, Ontario
OIP	Ontario Institute of Pedology, Guelph, Ontario
Planix 7	A digital planimeter
Procom-2	An optical transfer device whereby an interpreter can scan and enlarge one set of data and integrate it with a second data set
Parallelepiped Classifier	A means of separating image pixel values into classes based on a simple range rule. A pixel will be included in a class if it falls in the specified range; it will be excluded if it does not
Quarter Section	0.25 mi^2 or 160 acres (one fourth of a section of land)
Radar	Radio Detection and Ranging
RADARSAT	A Canadian radar satellite, now being developed through CCRS, scheduled for launch in 1990
RCM	Rural County Municipality (Province of Quebec)

Real-time (RT) Processing	A mode of data processing in which all analysis operations are performed at the same time and at the same rate as the data are collected
RLAP	Rural Land Analysis Program; provides a data base which attempts to link economic variables to the land resource base; used to identify areas of significant rural land-use change, the nature and extent of these changes, their significance relative to trends in other regions provinces, and to produce statistics quickly to assist in policy development (now called LANDBASE)
RM	Rural Municipality
RS	Remote Sensing
SIDMAP	Soil Inventory Database for Management and Planning
SLR	Soil-Landscape Relation
SPANS	Trade name for a type of GIS available from TYDAC Technologies Inc., Ottawa, Ontario
SPOT	Le Système Probatoire d'Observation de la Terre, Centre National d'Études Spatiales (CNES), France; satellite successfully launched in February 1986
SPSS-PC Software	Statistical Package for the Social Sciences – Personal Computer software; a complete information analysis system which performs advanced statistical functions, manages data files, and produces presentation-ready reports; uses an IBM PC
TEP	(Remote Sensing) Technology Enhancement Program; instituted in 1983 by CCRS to provide assistance to provincial agencies in adopting remote sensing technologies
TIROS	Thermal Infrared Satellite; the present NOAA series satellite is TIROS-N which has as its primary sensor the Advanced Very High Resolution Radiometer (AVHRR)
TM	Thematic Mapper; an Earth-observing sensor system with improved spatial resolution (30 m), spectral separation (7 bands), geometric fidelity, and radiometric accuracy
UCR	Urban Centred Region; component of the Canada Land Use Monitoring Program (CLUMP), Lands Directorate, Environment Canada
USLE	Universal Soil Loss Equation
ZTS	Zoom Transfer Scope; an instrument which enables an operator to view two materials, such as a photo and a map, in superimposition

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